PRACTICAL POINTS

IN THE USE OF

X-RAY AND HIGH-FREQUENCY CURRENTS

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HIGH-FREQUENCY CURRENTS

BY

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PREFACE

This book is intended for the general practitioner, who, having purchased an electrical outfit and desiring to make use of it, finds himself hopelessly at sea, not only in applying his various rays and currents, but in the use and care of the machine itself. When he naturally turns to the literature to help himself out, he is confronted with an abundance of books treating scientifically and in great detail of the things he wishes to learn, but which might as well be written in Greek for all his understanding of them.

In submitting these few pages on X-ray and high-frequency apparatus and the therapeutic application of the various currents, not only has no attempt been made at absolute scientific accuracy, but in many instances it has been sacrificed for the sake of presenting a clear picture to the student. It has been our misfortune in teaching to find that the use of technical phraseology and absolutely accurate scientific

definition has been to produce in the minds of many a confusion, which could have been avoided by definitions and phraseology, perhaps not quite scientifically true, and yet, in their practical application, much more useful and valuable in their understanding of the subject, the use of their apparatus and the application of their knowledge to diseased conditions.

For the student who has thoroughly mastered the following pages, and in the case of him who is already grounded in the principles of the science, we take pleasure in recommending *Freund* on Radiotherapy for a scientific exposition of our rays and currents; *Strong* for general treatment, more especially high-frequency currents; *Belot* for the man who wishes to take up diseases of the skin, and *Guilleminot* for general therapy.

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PART I

CHAPTER I

THE STATIC MACHINE

In this branch of electro-therapeutics, the result we attain is primarily to convert a current of low voltage and high amperage into one of higher voltage and lower amperage. This is called stepping up a current.

The best form of electricity for operating electro-medical apparatus is the one hundred and ten volt direct current. The next best is the two hundred and twenty volt direct. Then comes the one hundred and ten volt alternating current, and the two hundred and twenty volt alternating current. The five hundred volt current can not be used by means of a motor generator. When you write to any manufacturer for information in regard to any apparatus, always tell him the voltage of your current if it is direct; if it is alternating, state the voltage,

cycle and phase. Always have extra fuses on hand. Find out where the main fuse is placed, also the various cut-outs for the different circuits, so that in case a fuse blows out you can easily replace it. This will save loss of time and annoyance.

Our source of supply for the production of electro-therapeutic currents is mainly derived from the static machine and coil, to which may be attached various forms of high-frequency apparatus. In using a static machine we evolve our own electricity.

The coil, on the contrary, is simply a machine for transforming the street or other current from a current of low voltage and high amperage into one of higher voltage and lower amperage. For this purpose we have at our disposal two currents, the direct and the alternating, as already noted. If the direct current be used, it can be conducted directly to our coil. If the alternating current is used, however, a rotary transformer or rectifier must be interposed in the primary circuit. These transformers are supplied by the manufacturer selling the coil. The direct current, wherever practicable, is the preferable current for our work.

The Static Machine

The static machine is an instrument for producing a current with relatively high voltage and very small amperage. In its essential principle it is merely an elaboration of the old experiment in physics, by means of which electricity is generated by a glass wand and a silk handkerchief. The efficiency of the static machine depends upon the number and size of the revolving plates, together with the rapidity of their revolution.

The Component Parts of the Static Machine Equipment

(1) A rheostat for controlling the quantity of electricity supplied to the motor.

(2) A motor, which is connected by a pulley and belt to the axle, upon which are mounted the glass plates. A switch admits the street current to the rheostat.

The Rheostat. The rheostat is an instrument for controlling the quantity of electricity which flows through to the apparatus, either coil or to the motor of a static machine. The

most common variety consists of a continuous ribbon of metal attached to the back of a circular or square iron plate, insulated and fixed in position by means of porcelain. At intervals a metallic button is affixed to the ribbon. The metallic handle, with a wooden end for grasping, is so fixed that it can be moved along the metal

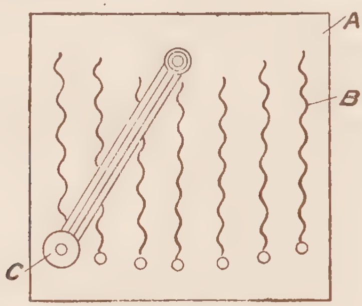


Fig. A.—Figure of a Rheostat.
The description will be found in the text pages 5–7

ribbon. The wire from the street current is attached to one end of the ribbon. Another wire is attached to the fixed end of the handle. By moving the handle across the disc, various buttons in turn are brought in touch with the handle, and upon the amount of ribbon through which the electricity flows, from the point of its entering the rheostat until its emergence at the handle, depends the quantity of electricity which

is allowed to flow through. By cutting out resistance we increase the quantity of current. (See Fig. A of Rheostat with diagram.)

It is not essential in the static machine that the electric current be used as a motive power, the electricity so used having nothing to do with the electricity, as will presently be seen, which is evolved by the plates. Any other motive power, even manual in small machines, can be used. Where the electric current is not available, the gasolene, water, wind or steam motor can be used with equal facility, provided it is large enough to produce sufficiently rapid revolutions of the plates.

(3) We now come to the essential features of the static machine. These are, in the composition plate machine, the large revolving plates attached to the axle, the stationary plates with foil attached, the collectors and the terminals. These are placed in a nearly air-tight glass case. In addition, many modern glass plate machines have also a primer. (See Figs. 1 and 2, Static Machine, glass plate or composition.)

A description of a motor is unnecessary, as its uses are so well known. We suggest the use of a fraction of a horse power greater than our

actual demands to insure sufficient power at all times.

Most static machines, if of glass plate, consist of from eight to twenty movable plates. With

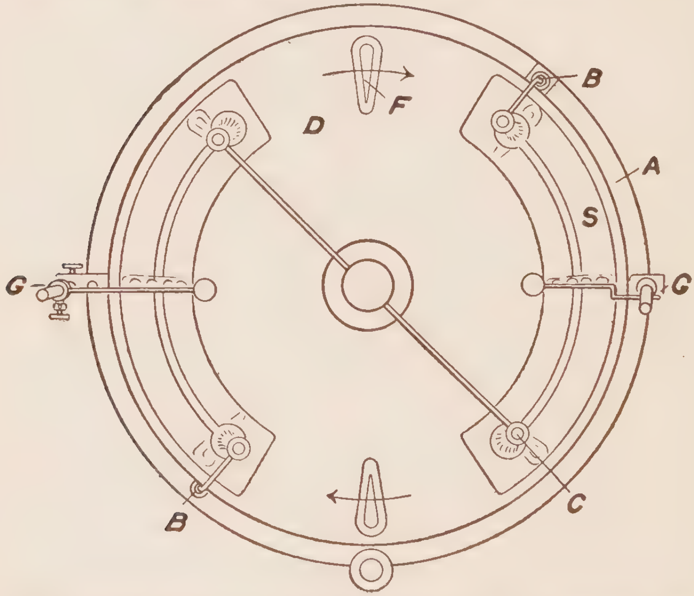


Fig. 1.—Represents a Toepler-Holtz Machine. "A" represents the stationary glass circle having the white paper with the tin foil strip "S" attached to it; "B" represents the brush connected with the tin foil strip on the stationary circle; "C" represents the neutralizing brush, "D" the revolving circle, "F" one of the metal sectors on the revolving circle. The terminals "G G" are where the current is taken off from the revolving circle.

a machine of less than twelve plates, radiographic work, involving hips, shoulders and viscera, can not be done; but with a machine of eight plates, fair treatment work can be accom-

plished. The composition plate machine depends upon great velocity of revolution for the production of the current. Consequently a larger motor is required for efficient work, and the cost of running same is materially increased.

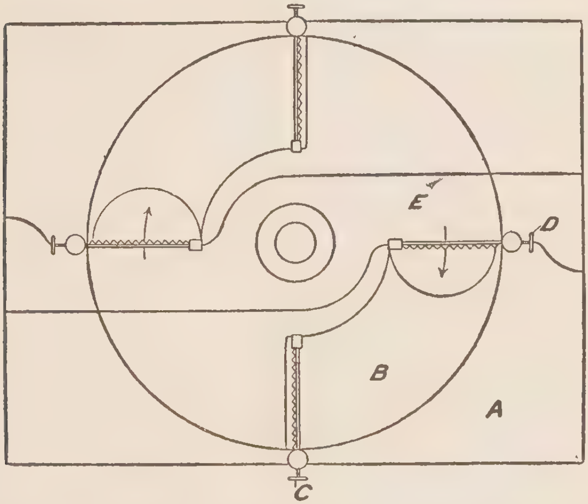


FIG. 2.—Represents a Holtz Machine. "A" represents a stationary plate, having the paper armature "B." "C" represents a neutralizing comb, "D," a collecting comb from which the current is conducted to the sliding rods of the main machine. "E" represents the revolving circle.

If this feature is not a consideration, very satisfactory work can be done with these machines.

A further description of the composition plate machine is essentially that of the glass plate, and can be omitted.

The Glass Plate Machine

In this country the *Wimshurst* is not manufactured for therapeutic purposes, but the prevailing types are the *Holtz* and the *Toepler-Holtz.* The latter is self-exciting and proves attractive to some on that account. If a *Holtz* and a *Toepler-Holtz* have equal areas of revolving surface, the output of current will be greater from the *Holtz;* when in action the *Holtz* machine will not change polarity, which the *Toepler-Holtz* is liable to do, especially when under a heavy load, when using the wave current or a high-resistance X-ray tube.

The Primer. The *Holtz* glass plate machines are provided with a primer, which is a miniature static machine in itself. It consists usually of two small glass discs, upon one of which are placed bits of metal. A brass brush comes in contact with these plates. By revolving these by means of a handle, frictional electricity is evolved upon the glass plates. This is carried to and back by means of wires, to the large plates. The principle of a primer is much the same as in the old-fashioned pump, where, by

pouring a dipper of water, we start the flow from the cistern.

The Collectors. These are a series of metallic rods, with teeth attached, something like an exaggerated comb. They are placed at intervals near the periphery of and parallel with the plates, and, as their name implies, gather up the electricity and conduct it to a common collector, by which, in turn, it is carried to the terminals.

The Terminals. These are large brass balls, situated outside and upon the front of the glass case, connected to the collectors by metal rods, and are about twenty-four inches distant from each other. Through these terminals are sliding brass rods, one end terminating in an insulated handle of rubber, the other tipped with a small brass ball. These are called the spark gap controls.

Accessory Apparatus. The Condensers. These are two *Leyden* jars, and each machine is usually fitted with two or more pairs of different sizes, depending upon the use we desire to make of them. They are placed upon a shelf attached to the case, directly beneath the terminals. This shelf has a copper floor, upon

which set the *Leyden* jars, the outside foil in contact with same. The copper floor is con-

Fig. 3.—Represents a complete Leyden Jar.

nected by a wire to a binding post for attachment of our treatment wires. The *Leyden* jar

Fig. 4.—Represents what is known as a flat condenser. "B" may be a piece of glass, mica or parafin paper, "A" a tin foil coating on one side, "C" a tin foil coating on the other side. This type of condenser is generally used with mechanical interrupters which are placed in the primary circuit of the ordinary X-ray induction coil.

has, running through its top, a metallic rod or chain, one end of which reaches the foil inside

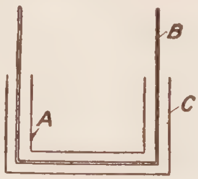


Fig. 5.—Illustrates a Leyden Jar. "B" represents the glass jar, "A" the tin foil lining inside, "C" the tin foil lining outside.

the *Leyden* jar. The other ends in a hook for attachment, when desired, to the sliding rod of

the terminal. (See Figs. 3, 4 and 5, Condensers, Leyden Jar and Plates.)

The Crown. This is used for the production of the breeze or static spray, and consists of a brass crown-shaped ring with serrated edges with a long brass arm attached to the upper portion of the case. A chain is usually connected with this arm, running inside the case to one terminal.

CHAPTER II

THE STATIC MACHINE—(*continued*)

HAVING now described the static machine, we will proceed practically to evolve electricity and apply the various currents we produce to the treatment of our patient, leaving a description of the therapeutic and physiological action for a later chapter.

If we assume that the electric current is to be used as motive power, we know that one wire is attached to the rheostat. This wire continues out through the handle of the rheostat, and is carried to the motor, from which it returns by means of another wire to the street current. A switch is interposed between the rheostat and the street current. If we are using other power than the electric current, of course the machine will be started and stopped by the motor used.

We now set our rheostat about one-third of the way over, press down our switch to make connection with the street current, and, in the case of the *Holtz* machine, revolve our primer

rapidly and continuously. In the *Toepler-Holtz*, this is, of course, unnecessary. As our large plates gather motion, we gradually move the handle of our rheostat over until somewhat more than one-half our buttons have been put successively in play. Our sparks, which have been jumping across between our terminals, have grown more and more rapid and vigorous. We cease revolving our primer, and if we have been fortunate in producing sufficient electricity upon our large plates, our machine is working. After this, it is only essential to regulate the speed of our machine by the rheostat.

The rheostat, in all electrical work, should be brought not too suddenly into play, allowing our machine to pick up gradually, as otherwise, by suddenly bringing too great a strain, we may injure our motor or blow out our fuse plug.

In humid weather it is sometimes difficult to obtain a charge for our large plates, and if we find, upon ceasing to revolve our primer, that our spark ceases, we must resume our work, and in case we still fail to get a charge, stop the revolution of our large plates by throwing off our switch and begin again. Even this is sometimes ineffectual.

When this occurs it is necessary to open up the glass case, thoroughly dry it out by means of a fire built in the room, and by placing in the case calcium chloride in dishes. Sometimes the moisture will be so considerable as to liquefy or reduce our calcium chloride. It must then be taken out and a fresh supply introduced. A more detailed description of the care of the machine will be found on another page.

It is essential for the proper working of a static machine that the metallic parts outside the case be kept carefully cleansed and polished.

The Static Current. By this is meant a current produced by the static machine in the manner above described. It is essentially a current of very low amperage, but of high voltage.

The Static Induced Current. This current was first described by *Morton*, and was our first effort toward a high-frequency of interruption current. It is not a true high-frequency current, although it has its uses. It is produced by carrying the current from the terminals through the condensers or *Leyden* jars, and its rapidity of interruption and the quantity of electricity behind each individual interruption is determined by the distance apart of our spark gaps

(which with the average jar should not exceed one-fourth of an inch), the capacity of our *Leyden* jars and the number, size and rapidity of revolution of our plates. This current has always a *higher frequency of interruption* than our static, but varies in relation to itself, this variation being determined, as stated, by the distance apart of our spark gaps and by the amount of foil contained in the *Leyden* jars, together with the number, size and rapidity of revolution of our plates. The regulation of these factors regulates the quantity of current in each discharge. The closer the approximation of our spark gaps, the greater the rapidity of discharge, and, consequently, the smaller quantity in each individual discharge. It will be seen that all these factors enter into both the rapidity of discharge and the quantity of current behind the individual discharges.

The effect of the static-induced current is to rapidly charge and discharge our patient with electricity. It produces an extensive tetanization of the muscles, which lasts during the charge. It is extremely disagreeable, to say the least, and may be dangerous to life to give too heavy a charge, *i. e.*, to pull our spark gaps too

far apart. A fraction of an inch, the distance determined by the feelings of the patient, is all that it is safe or desirable to use.

Methods of Treatment by Means of the Current Derived from the Static Machine

The application of the current is effected by means of chains. One chain may be attached to a gas or water pipe, forming a ground, or it may end in a metal handle or plate, which the patient may hold in his hand or upon which his foot may be placed. The other wire may be attached to the crown spray placed over the patient's head, or it may end in an electrode, either of metal or glass, which may be applied to any part of the patient's body. The patient may be placed on an insulated, glass-legged platform or in a chair on the floor.

Metallic electrodes are of various shapes, sharp-pointed, with single or multiple points, or in the form of a roller or brass ball of various sizes. The discharge from the metal electrode varies with the extent of surface, the points giving a fine, irritating spark, the ball a large, heavy bombardment. Glass electrodes consist

of a low vacuum tube set in a metal, insulated handle, and are of various shapes, depending upon their use. The bombardment from the glass electrode is much smoother and less irritating to the patient than that from the metallic, but is used principally with the high-frequency currents.

In using the static current, the chains are attached directly to the terminals—in the static-induced current, to the binding posts beneath the *Leyden* jars. The current that the patient receives depends upon the number and rapidity of revolution of the plates, and upon the distance apart of the spark gaps. This position of the spark gaps is called the spark-gap length.

The direction of flow of the current in a static machine varies. It may change each time the machine is started, and rather infrequently changes while the machine is in motion. It is determined in several ways. The two simplest methods are, first, the observation of the spark between the metallic balls of the spark-gap control. The fattest spark is supposed to be upon the negative side of the machine. It is, however, sometimes difficult to determine which is the fattest spark. Another and surer method

is to pass a wand of any non-conducting material (a wooden broomstick or rolled-up newspaper will do) between the metallic balls. The current will follow the wand upon the positive side.

Where it is desired to accentuate the effect of our current, the patient is often placed upon a platform with glass legs, which prevents the grounding of any part of our current.

Care of the Static Machine

At the present time there are only two types of static machines in use in this country. One is known as the *Holtz* induction machine, the other as the *Toepler-Holtz* machine. The *Holtz* as constructed has inside of it a small machine of the *Toepler-Holtz* type, which is used to prime the *Holtz,* as the *Holtz* is not self-charging. When a machine fails to generate, if it is of the *Holz* type, the first thing to look after is the priming machine. Notice whether, when this is operated, a spark appears on the brushes. If it does not, the first thing to do is to remove the brushes and cut the ends so that they present a fresh surface. The little metal sectors on the revolving plate of the primer are to be cleaned with a very fine sandpaper.

If the brushes have been renewed several times, examine the plate carefully alongside of the sectors, as sometimes the lacquer becomes worn off. When this occurs, the only thing to do is to put in a new revolving plate. If the inside of the machine feels sticky and if the revolving circle is also sticky, it should be removed and cleaned with a little kerosene oil on a cloth in the same way that you would clean a piece of furniture. The kerosene oil will remove all of the oxidized material without injuring the lacquer. The inside of the case can also be cleaned in the same manner. After this is done, the quickest way to start the machine going is to place inside of the case several glass jars which are filled with ice and salt in the same proportion as used for freezing ice cream. The jars should be placed in saucers, as the first condensation will be in the form of water. After they have been left inside of the case for one hour and a half, if the mixture is right, a heavy coating of frost will have formed on the glass jars, and you will find that the machine will now generate. On the following day you can place inside of the machine four or five pounds of baked chloride of calcium and twenty or thirty

pounds of unslaked lime. This latter should be placed in bags made of cheesecloth and then placed in boxes. Whenever the inside of the machine needs the above treatment, it will also be indicated several days before the machine will refuse to work in the following manner: You will notice that, when the machine is started up, instead of charging easily, you will have to operate the primer two or three minutes. When you notice this condition the machine should be thoroughly aired out and fresh calcium and lime put in. If this is done, there is no reason why the machine should not operate satisfactorily the entire year. If the large machine is of the *Toepler-Holtz* pattern, when it ceases to generate, it should be treated in exactly the same manner as above described for the primer of the *Holtz* machine.

The Use of the X-Ray Tube with the Static Machine

We attach the two wires already mentioned for treatment purposes, one to the positive or anode end of our tube, the other to the negative or cathode end. In this connection it may be said that we can determine the direction of the

current by the light produced in the tube. Where the light is steady and greenish in color, we know that our current is passing correctly. Where, however, in place of this lighting up of the tube, we get concentric rings of light flashing across the globe, we know that our tube is improperly coupled to the machine. This is called reversed polarity. By removing the tube

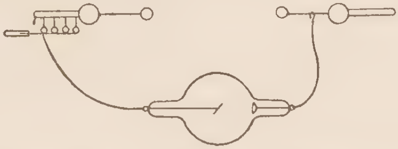


FIG. 6.—Shows an X-ray tube connected in series with a multiple spark gap, attached to a Static Machine.

and replacing it in the opposite direction, we obviate this difficulty.

Auxiliary Spark Gaps. These are used in a static machine to control or steady the current in the X-ray tube. They consist of any number of brass balls desired, affixed to a non-conducting material, through which slides a brass rod with insulated handle. Our wires are attached to the balls at either end. By withdrawing the rod, the current jumps from ball to ball. The description of this action will be given in detail with the coil. (See Fig. 6.)

CHAPTER III

THE COIL AND ACCESSORIES

In using a coil for the production of a current suitable for electro-therapeutic application, we are transforming the current from a current of low voltage and high amperage into one of higher voltage and diminished amperage.

We have two currents most suitable for use in the coil, the direct current (*Edison's*) and the alternating current. These vary from one hundred and ten to two hundred and twenty volts, from two to ninety amperes. This has been further explained on another page.

The various pieces of apparatus used are the rheostat for measuring the quantity of current, the interrupters, the *Rhumkorff* or induction coil, the spark gaps, and usually the ammeter.

The rheostat has already been described in connection with the static machine.

Interrupters are of two main varieties, mechanical and electrolytic.

Mechanical interrupters are again subdivided into vibratory and mercury jet or oil interrupters. Electrolytic interrupters are divided into *Wehnelt* and *Caldwell* interrupters.

Mechanical Interrupters or Circuit Breakers for X-Ray Coils

There are three types now in use, the most common one being that known as the mercury-jet. As a rule, this type of interrupter has placed over the mercury some petroleum of varying degrees of density, each manufacturer recommending a particular oil best suited for his individual construction of this type of interrupter. At the present time, in England, instead of using an oil, ordinary illuminating gas is used. The disadvantage of the oil covering over the mercury is that, after running a varying length of time, the oil becomes mixed with the mercury so that the mercury no longer conducts the current. When this change is beginning to take place, it is indicated by an irregularity in the spark from the coil. The only thing to do is to take the interrupter apart and thoroughly filter the mercury.

The Mercury-jet Interrupter depends for its efficiency upon the make and break produced

by minute globules of mercury traveling between two fixed connecting wires. It consists of a steel cylinder with a cup-shaped depression at the bottom. Into this cylinder fits a hollow steel tube, with hollow arms projecting at right angles. The tube has an inner spiral. Upon the top of the tube is a pulley, which connects by means of a belt to a motor, or in some forms of interrupter is connected directly, without the intervention of pulley or belt. The revolutions of the motor produce more or less rapid revolutions of the shaft, the motor, of course, being controlled by a small rheostat. In the bottom of the steel cylinder is placed about five pounds of pure liquid mercury. A connection is made by means of a plate and wire to the bottom of the cylinder, by means of which the mercury is electrified. Upon revolution of the hollow tube, the mercury is sucked up and sprayed out through the hollow arms in minute globules, against plates set about one-eighth of an inch away from the upper outlet in the side of the cylinder, these plates being also connected by means of wires joined to one common wire. The top of the cylinder has an air-tight steel cap, through which the hollow rod projects. It will

be seen that the rapidity of the make and break in the current depends upon the number of revolutions of the hollow tube, controlled by means of the motor. (See Fig. 7, Mercury Interrupter.)

Mechanical Interrupters are useful for treatment work, as they require only a small quantity

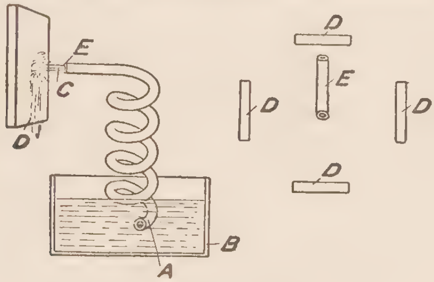


FIG. 7.—MERCURY-JET INTERRUPTER.

When "A" is revolved by means of an electric motor, the mercury from "B" is carried up through the coil and strikes against one of the contact plates "D," thus closing the circuit. As a rule this break has a mineral oil several inches deep over the top of the mercury so as to absorb the spark. It makes a very disagreeable style of interrupter and is being used less and less each year.

of current. They are easy to manipulate, are odorless and require little attention. Their objections are that they are noisy and expensive compared with electrolytic interrupters, and hardly as reliable. In the mercury-jet interrupter, the mercury tends to become oxidized. It also collects considerable dust. When it is found that the rate of interruption is becoming irregular or ceases altogether, the top of the

metal case, the dasher and mercury should be removed, and the mercury poured a number of times through a filter made of cheesecloth. The dasher should also be cleaned with a small brush. This removes the dirt, and by adding a small quantity of mercury and replacing, the interrupter will work as well as ever.

Note. It is well for those with sensitive naso-pharyngeal mucous membranes, to protect themselves in cleaning the interrupter by means of a muffler over the nose and throat, as the dust arising from the mercury is extremely irritating in those in which oil is not used.

Motor Vibrator. This is another type of mechanical interrupter, where, instead of using mercury to interrupt the current, the current is broken between two silver or platinum contacts, which are usually about half an inch in diameter. These surfaces are brought in contact and separated again by means of a cam attached to the shaft of an ordinary electric motor, which is operated by a separate and distinct current from that used to go through the primary of the induction coil. The advantage of this type of interrupter over the mercury-jet is that it is very much easier to keep in good working order, takes

up very little room and can be operated at a very much slower rate of interruption. It also has the additional advantage of being much cheaper. (See Fig. 8.)

Ordinary Vibrator Type of Mechanical Interrupter. This is constructed on the same general

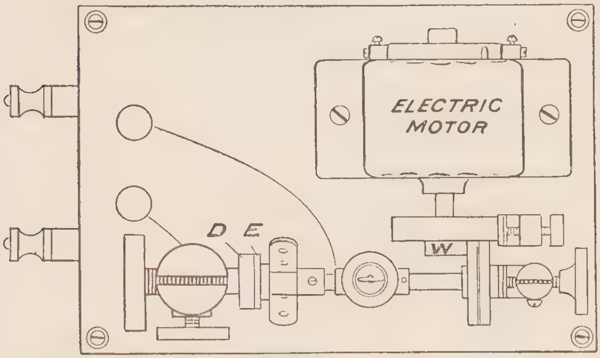


FIG. 8.—MOTOR CIRCUIT BREAKER.

When the electric motor is in operation, it causes the section "E" to move back and forth so that the current is made broken between the two large contact surfaces "D" and "E." This operates very satisfactorily with currents of not more than five or six amperes.

plan as the vibrator used on the ordinary faradic medical coil, the only difference being that it is very much larger, and instead of small contact points they are made at least half an inch in diameter, the same as on the interrupter above described. This makes the simplest type of mechanical interrupter, but, like the mercury

interrupter, it can not be operated at as slow a rate as the one run by the separate motor. (See Fig. 9.)

Electrolytic interrupters. These depend for their efficiency upon the decomposition of sul-

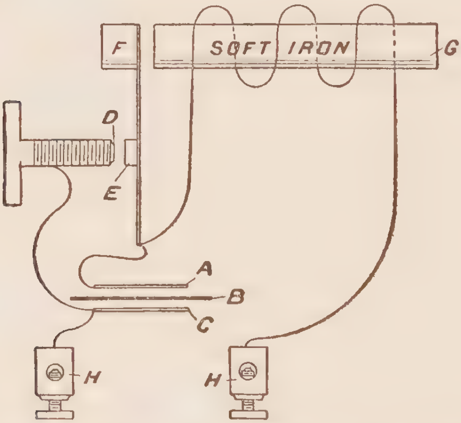


Fig. 9.—Illustrates the latest type of vibrating circuit breaker. "A B C" represents a mica condenser, the binding posts "H" and "H" are connected in series with the X-ray coil. The circuit is made and broken at "D" and "E." These contacts are very large, being about ½″ in diameter. This operates most satisfactorily in conjunction with an X-ray coil that is used for X-ray treatment or for operating high frequency transformer. It requires practically no attention and always works. It makes very little noise.

phuric acid and the liberation of hydrogen. The hydrogen bubbles being electrified, carry minute charges of electricity between two terminals of similar or dissimilar metals immersed in the sulphuric acid.

The Wehnelt Interrupter. This consists of a glass or porcelain jar, filled for about one-third its depth with a solution of sulphuric acid and water, from one in four to one in ten. Into this jar projects a lead coil, or a lead collar is clasped about a central, hollow, porcelain tube. Through the hollow porcelain tube descends a rod of lead, to which is soldered a platinum tip. The platinum tip projects through a minute opening in the end of the porcelain tube, which fits tightly about it (much like a patent lead pencil) into the solution. The amount of exposed platinum is regulated by a thread-screw at the upper end of the porcelain tube. One arm, the positive, is connected to the platinum—the other, the negative, to the outside lead rod. When the current is turned on, the decomposition of sulphuric acid produces hydrogen bubbles, which carry their charges of electricity between the lead and platinum. The number of interruptions in a given time will depend upon the quantity of electricity which flows through the wire and the amount of platinum exposed. These interrupters are convenient because they can be easily regulated, and are suitable for radiographic work, where the amperage behind the current must neces-

sarily be great. They are expensive, on account of the rapid erosion of platinum and the necessity of somewhat frequently replacing the porcelain tube.

A practical point worth noting in the use of the *Wehnelt* interrupter, is that the porcelain tube in its erosion forms a cup-shaped or concave depression. This allows the current to become irregularly interrupted. One second the ammeter will show a considerable amperage, at the next, practically none. The fluctuation in the current is also shown by the irregularity of the light in the X-ray tube. When this occurs, a new porcelain tube must replace the old, or we are in danger of blowing out our fuse or puncturing our coil. (See Fig. 10, Wehnelt Interrupter.)

The Caldwell Interrupter. In its principle, this is much the same as the *Wehnelt.* It consists of a glass jar partly filled with the same solution of sulphuric acid and water, the outside lead rod also descending into the solution. In this interrupter the porcelain tube is replaced by a porcelain cup. Inside this cup descends another lead rod or coil. One or more minute holes are drilled in the porcelain cup, which is

swung by means of a support to the lips of the glass jar. The wires are connected to the two lead rods. As we have a similarity of metal in this case, it makes no difference which pole is

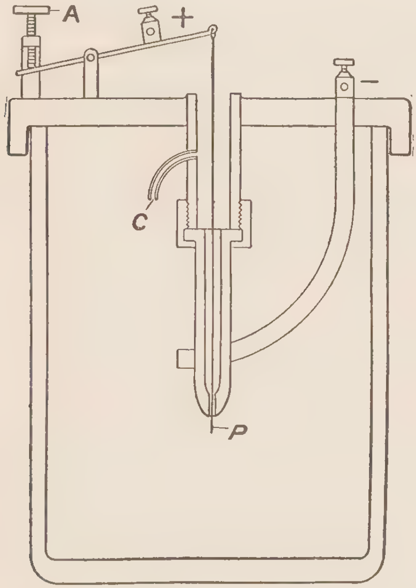


FIG. 10.—WEHNELT INTERRUPTER.

"P" represents the platinum point coming down through the porcelain stem. As the adjusting screw "A" is regulated, it allows this point to extend more or less. The more it extends, the more current passes through the solution.

plus and which minus. When the current is turned on, the same action occurs as in the *Wehnelt* interrupter, in this case the number of interruptions depending upon the quantity of

current and upon the number and size of the holes in the porcelain cup. This interrupter is useful for treatment work, is cheap and fairly constant. The rate of interruption, however, can not be changed except by substituting cups

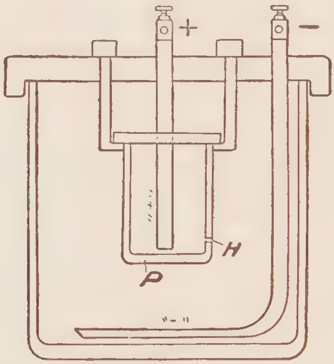


Fig. 11.—Represents the Caldwell Interrupter. This consists of an inner porcelain jar "P" having one or more holes through it "H." In the outer jar is placed a lead electrode marked "—." In the inner jar is placed another electrode marked "+." The solution used is sulphuric acid and water. When the current is passed from the inner jar to the outer jar through "H" the current is interrupted. This type is not used as much as formerly owing to the breakage of the inner jars and to the fact that the hole "H" gradually wears a little larger, and after a while becomes so large that the current does not interrupt.

with larger or smaller holes. As a rule, the cups are drilled so as to admit of from three to six amperes of current being used. (See Fig. 11 Caldwell Interrupter.)

Note. There is a tendency toward erosion and consequent enlargement of the holes in the

cup, with a consequently gradually increasing amperage, so that the cups must be changed from time to time. This, of course, can be detected readily by watching the ammeter.

Electrolytic interrupters are cheap, convenient and require little attention. The solution tends to increase in strength, and must be diluted from time to time. In the *Wehnelt* interrupter, the platinum tip will also require occasional replacement. The lead lasts practically indefinitely. The objection to these interrupters is the fumes which arise. They are also very noisy. This can be obviated by placing the interrupters out-of-doors or in a separate room.

The Coil. The *Rhumkorff* or induction coil, in its simplest form, consists of a core of soft iron called the primary, wound around which, but separated from it by means of insulation, is a winding of coarse copper wire, each winding of this wire being separated from every other winding, also, by insulation. This is the complete primary. A current passed through the primary, induces another current in a reverse direction in the secondary at the make. The action of a magnet in inducing magnetism in a soft piece of iron by means of which iron filings can

be picked up by the iron, is a good example of the action of the coil. When the current is turned on, the primary becomes a magnet, which, in turn, magnetizes the secondary.

Description of the Coil. The efficiency of a coil depends upon the length of the primary, plus the number of windings and size of the wire in the secondary, and is measured by the number of inches and character of the spark that will jump across between the two ends of the secondary wire. Thus, a six-inch coil means that a spark will jump across the atmosphere six inches between the exposed ends of the wires in the secondary; a twelve inch, twelve inches, and so on.

In the earlier days of electro-therapeutic work, it was considered necessary, to do good work, to have very large coils. At the present time, very satisfactory work, even in radiography, which requires the most efficient coil, can be accomplished with one of twelve inches spark-gap length.

The modern coil consists, first, of a core of soft iron, around which is an insulation of paper. About this is wound one or more layers of coarse, copper wire. This comprises the primary. This

is insulated in its turn by paraffin or some composition, from the secondary. The secondary consists of innumerable windings of fine copper wire, insulated from every other winding and from the primary by means of hard rubber. The secondary windings are put on in sections, so that in case of puncture, *i.e.*, of failure of the insulation with consequent short-circuiting between the wires, only a portion of the secondary need be replaced. The two ends of the windings in the secondary are brought up through the jacket at opposite ends of the coil, and become the terminals. Attached to either one or both of these terminals, is a sliding metallic rod or lever. By approaching or withdrawing these rods from each other, the length of the spark gap between the terminals is controlled. The distance between these rods should never be as great as the capacity of the coil. That is—in a twelve-inch coil, the poles should be placed six inches, eight inches or ten inches from each other, depending upon the quantity of current that we desire at the time. (See Fig. B, Rhumkorff coil.)

Ammeter

This is an instrument for measuring the quantity of current used in the primary circuit of the X-ray coil, and is a most important instrument and should be a part of every X-ray equipment, as by means of it the operator can tell just how much current he is using. In the simplest form,

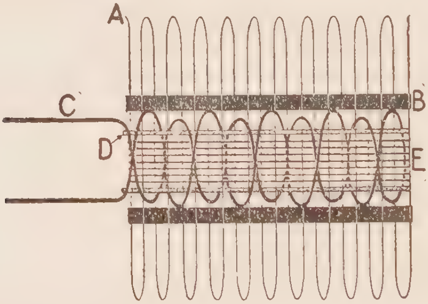


Fig. B.—Figure of an Induction Coil.
The description will be found in the text pages 36-37

it consists of a steel needle balanced on a point, the same as used in the ordinary compass. Underneath this is placed a coil of wire through which the current passes. The stronger the current, the further the needle is deflected from zero. As usually constructed for commercial purposes, however, there is in addition a coil spring, which brings the needle back to zero as soon as the current is shut off.

Multiple Spark Gaps

These are made in two styles. One style consists simply of a row of brass balls, mounted on an insulating rod and separated about one-eighth of an inch from each other. A rod is arranged to slide over the top of the balls, so that a spark gap can be used of from one-eighth of an inch up to about two inches. The other type consists of a series of points placed about one-sixteenth of an inch away from a metal disc, usually an inch in diameter. Multiple spark gaps are used for the purpose of cutting out the inverse current, also for adding resistance to the circuit in which the X-ray tube is placed. By means of them it is possible to operate an X-ray tube the vacuum of which would be so low, that, without them, hardly any X-ray would be obtainable; but by means of them, an X-ray can be obtained which would be sufficient for radiographic purposes of the extremities. They are also of great benefit when using the fluoroscope, as by means of them the penetration of the X-ray can be easily varied without changing the primary current. (See Fig. 12)

Oscilloscope

This important little device consists of a glass tube about four inches long and one inch in diameter. Inside of it are placed two metal rods, one-eighth of an inch in thickness and

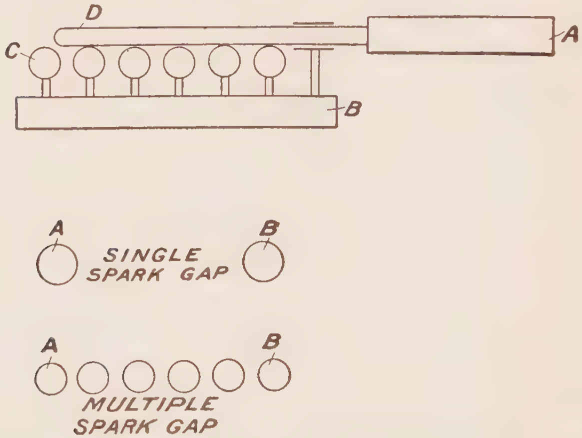


Fig. 12.—Represents a series multiple spark gap for use in circuit with an X-ray tube. The advantage of the multiple spark gap over the single is that a spark will be very much more steady when passed through a series of metal balls than when one single gap is used.

about one-sixteenth of an inch apart at the middle of the tube. This tube is now exhausted to what is known as the *Geissler* vacuum. This is a low vacuum. When this device is in circuit with an X-ray tube, it shows the presence of inverse currents. When the current is unidirectional, you will notice a violet color on one

of the metal rods. If there is a little inverse, you will notice a little violet color on the opposite

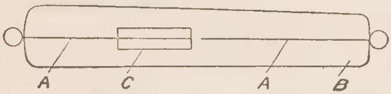


FIG. 13.—Shows an Oscilloscope which consists simply of a straight glass tube "B" having two wires "A–A" sealed in it and brought within about 1-16″ from each other. When connected with a uni-direction high voltage current, the violet color appears on the negative rod "C." The length of this color depends upon the number of milliamperes in the circuit.

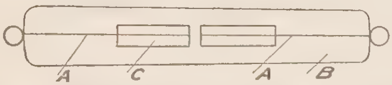


FIG. 14.—Shows an Oscilloscope indicating an alternating or oscillating current. This is indicated by the fact that the violet color shows equal length on each rod.

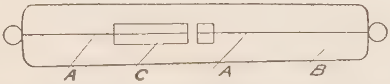


FIG. 15.—Shows an Oscilloscope indicating a small amount of inverse which is shown by the short violet color on the other rod.

metal rod. If the current is alternating, the violet color will be equal on both rods. (See Figs. 13, 14 and 15.)

Villard Valve Tube

This is a device for cutting out inverse current. It consists of a vacuum bulb having a spiral electrode placed at one end of it and a small rod at the other end. As long as the

spiral end is negative, the current flows freely from the small rod at the positive end; but as soon as the spiral end is positive, it tends to hold

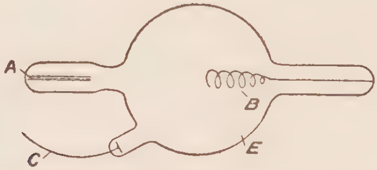


Fig. 16.—Illustrates a self-regulating Villard Valve. When this is placed in series with an Oscilloscope which, without the valve tube, will indicate, as shown on Fig. 14, when the valve is placed in circuit with it, the Oscilloscope would indicate according to Fig. 15. This should be used with every induction coil.

back the current. As this device is commonly made, it has a self-regulating attachment for keeping its resistance constant. (See Fig. 16.)

Tracing the Current through a Coil

We will now proceed to trace the current through the primary circuit. Starting with the initial current, we have two wires. One of these will be attached to one end of the rheostat. The current will flow from there through the rheostat to a wire attached to the base of the handle. The quantity of current passing through will thus be regulated by the amount of the ribbon of metal which is included in the circuit, this in turn being controlled by the position of the han-

dle. The wire is then carried either to the ammeter or interrupters, its position in the primary current being an indifferent one. Through the ammeter, we trace the current to the interrupter. It is usual to have two interrupters connected by means of a bipolar switch, so that either can be placed in the circuit. This is useful in giving us an interrupter for treatment purposes and one for radiographic work. If we wish our apparatus very complete, we may have a mechanical interrupter, and by a further arrangement of switches, a *Wehnelt* interrupter, in addition, for our photographic work. (See Fig. 17 showing how this is accomplished.) The wire is carried, then, through the interrupters, in the case of the *Caldwell* it being a matter of indifference which wire is attached to the outside and which to the inside lead rod. Where the *Wehnelt* interrupter is used, the positive pole is always attached to the inner lead rod, ending in the platinum tip. We now carry the wire to the primary of the *Rhumkorff* coil, through the primary and back to the other street wire.

When our button or switch that connects with the street current is thrown over, the current

passes to the rheostat, the quantity of current being controlled by the lever; through the ammeter, which registers the quantity of current we are using; through the interrupters, which split

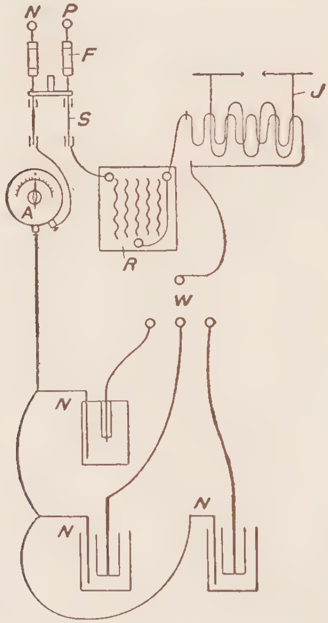


Fig. 17.—Represents the way of connecting all three interrupters so that either one can be used as desired. "A" represents the ammeter or the rheostat, "W" the selecting switch, "S" the main line switch for turning the current on and off.

up our current, changing it from a continuous unidirectional current to a rapidly interrupted current (the number of interruptions depending upon the holes in the porcelain jars in the

Caldwell interrupter, the quantity of platinum exposed in the *Wehnelt* interrupter, the rapidity of revolution of the dasher in the mercury-jet interrupter or the number of vibrations in the mechanical interrupter), into and through the primary and back to the street current.

The passage of the current through the primary induces a current in the opposite direction in the secondary at the make, at the break the secondary current is again reversed. This is called the secondary current.

As has already been described, the opposite ends of the wire in the secondary are brought up through the insulated case at the opposite extremities of the coil. These are called the terminals.

In most modern coils, for the purpose of still further interrupting and regulating the flow of the secondary current, a number of brass balls fixed to a hard rubber rod are attached. By means of a sliding rod one or all of these balls can be brought into play, the current traveling from the terminals to the most distant ball.

A movable rod or pointer is also attached to one of the terminals. This, by being approximated or withdrawn from the opposite terminal,

controls the quantity of current which is allowed to flow through the spark gaps and out along the secondary circuit. When the pointer is approached nearly to the opposite terminal, a part of the current will be carried between the two terminals, and so, once more, to the secondary. When the pointer is withdrawn a greater quantity of current will flow through the spark gaps.

To the most distal of the brass balls is an attachment for the wires by means of which we connect our X-ray tube to our coil. (See Fig. 12.)

The current produced by a coil, as has been seen by the foregoing, is a stepped-up current. That is, we have changed a current of low voltage and high amperage into a current of decreased amperage with a greatly increased number of interruptions and voltage, in the average coil about one hundred and twenty thousand, with a correspondingly diminished amperage. This current still contains too high an amperage and is too irritating to the tissues to be used for electro-therapeutic work. On the other hand, it is the ideal current for X-ray work.

As will later be seen, an X-ray tube can be

sufficiently excited for treatment purposes by means of a small static machine, which produces a current of small amperage; but for radiographic work, especially where large joints and deep structures are to be taken, only a current with considerable amperage behind it is effectual. For this purpose a coil developing a considerable quantity of current, *i.e.*, a current of high amperage, is required.

To make our coil useful for electro-therapeutic work, other than for the production of X-rays, it is necessary that we still further step up our current—that is, make it a higher-frequency current, a current of greatly increased voltage and correspondingly diminished amperage. This is accomplished by adding certain apparatus to be described in our next chapter.

CHAPTER IV

HIGH FREQUENCY APPARATUS

The essential mechanism used in the production of high-frequency currents, as usually obtained, consists, first, of a static machine for producing or a coil for changing our initial electric current. Connected with the above are (a) one or two condensers. In circuit with the condensers is placed (b) a solenoid and a spark gap for discharging the condensers. Connected with each end of the solenoid are binding posts, from which the current is taken. This form of high-frequency current is known as the *d'Arsonval* and is a high-frequency current of relatively low voltage and high amperage. It is not usually used with vacuum electrodes. This current is applied to the patient in one of three ways—(1) derived or shunt method; (2) auto-condensation method; (3) auto-induction method.

Additional mechanism which can be used consists of (c) a *Tesla* coil, (d) an *Oudin* resonator, and, in some cases, (e) an additional large sol-

enoid, and (f) an auto-condensation couch or chair. The *Piffard* intensifying electrode has been developed to take the place of the *Oudin* resonator, and works very satisfactorily. We also have electrodes, metal and glass, for the purpose of applying our currents to our patients.

The credit for the introduction of vacuum tubes in connection with the therapeutic application of high-frequency currents belongs to *Dr. F. F. Strong*, of Boston.

The Condensers. The earlier form of condensers consisted of glass jars, commonly called *Leyden* jars, with a coating of foil both inside and outside the glass, to the outer and inner layers of which were attached wires. At the present time, condensers are made, not only of the above pattern, but also of mica or glass plates separated from each other by layers of foil, much like a jelly cake, the upper and lower layers of which are connected by wires. The capacity of the condenser depends upon the amount of foil contained. (See Figs. 3, 4 and 5.)

Note. These condensers have been described in connection with the static machine in producing the static induced current. The charge and discharge of the condensers is controlled by

means of a spark gap, *i. e.*, sliding rods already described, the distance apart of the metallic points controlling the rapidity and quantity of the individual discharge.

The "Hyperstatic Transformer" of Piffard. A primary of coarse wire is wound as a solenoid around a heavy glass tube, inside of which is the fine-wire secondary with its terminals projecting from the ends of the case. The terminals of the primary are connected to the external foil of the jars, and from these connections is obtained the *d'Arsonval* current. The internal foil of the jars is connected to the terminals of the static machine, which is usually operated with a spark-gap of about two inches. "When the instrument is constructed with the capacities in proper relationship to the initial current (from the static machine), the primary and secondary coils in harmony therewith, the effluve and sparks from one of the terminals of the secondary (the other terminal being grounded) resemble in character those obtained from a resonator, and may be applied to the same uses." (See Fig. 18.)

The Tesla Coil. The essential features of the *Tesla* coil, as of the *Rhumkorff* coil, consist of a primary and a secondary. Their arrange-

ment, however, differs radically. In the *Tesla* coil, the primary consists of a single helix of coarse copper wire, wound around a hard rubber cylinder open at either end. Both primary and secondary are immersed in an insulating oil. The wires from the condenser are attached at

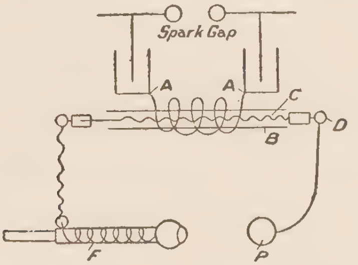


Fig. 18.—Above figure illustrates a Tesla Transformer. As designed by Nicola Tesla, the two coils were insulated from each other with oil. Dr. Henry G. Piffard modified this construction for medical use by using a hard rubber or glass tube to separate the primary from the secondary windings. The current from the terminal "D" has the same character as the current from the top of the resonator. He also found that, by a second winding on a separate handle and attaching it to one terminal of the Tesla and connecting the patient with the other terminal of the Tesla, a still longer spray could be obtained. This he called an intensifying handle.

either end of the helix. Inside the cylinder is another winding of fine copper wire, wound around a cylinder of small diameter. The ends of this secondary are brought out, and become the terminals for the *Tesla* current. The whole is enclosed in an insulation of hard rubber. *Piffard's* improvement consists in substituting

glass for hard rubber, doing away with the oil and bringing out wires at a point just after the first and last turns of the helix. These wires become the terminals for the *d'Arsonval* current.

Essential Points of Difference Between the Tesla and the Rhumkorff Coil. The disparity between the size of the copper wire in the primary and in the secondary is greater in the *Tesla* coil, No. 12 usually being used for the primary and No. 36 for the secondary. Copper wire is used both in primary and secondary in the *Tesla* coil, while soft iron is used for the primary core in the *Rhumkorff*. Again, the primary is usually outside the secondary in the *Tesla* and inside in the *Rhumkorff*. The insulation in the *Tesla* between primary and secondary, which is more or less incomplete, is a glass cylinder, and the secondary consists only of a single winding of wire. (See Fig. 18, Diagram of Tesla coil.)

Oudin's resonator is simply a cylinder about eight inches in diameter and twenty in length. Around this a copper wire is wound and one end of it connected to the *d'Arsonval* solenoid. The other end is free, and from it, when the apparatus is in action, a fine electric spray or effluve

is given off under a much higher potential than the original current. This effluve can then be conducted to any part that one may desire to locally affect. This current is of higher potential than the *d'Arsonval* current.

The Large Solenoid. This is rather a cumbrous piece of apparatus, and on that account

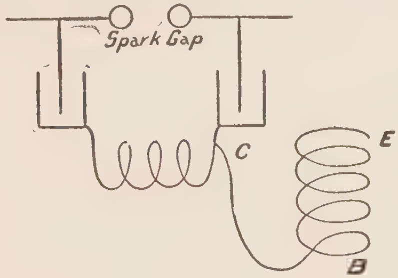


FIG. 19.—OUDIN RESONATOR.

Doctor Oudin found that by connecting the large solenoid of d'Arsonval to one terminal of the small solenoid of d'Arsonval, from the top of the large solenoid he would obtain a long spark, which varied according to the point of contact from the large solenoid on to the small solenoid. In order to make this more convenient, he designed an apparatus as shown in Fig. 22.

not very greatly used at the present time. It consists of a helix cage (*d'Arsonval*) something like a mouse-trap, of size sufficient to contain a man, connected to the small solenoid by means of a wire, or a spiral placed at the top of the large solenoid (*Piffard*). It is usually attached by means of a pulley and rope to the ceiling, so

that it can be raised and lowered to admit the patient. (See Fig. 20, Solenoid.)

The Auto-Condensation Couch usually consists of a table with insulated legs, upon which is placed a woven wire screen or mattress. One wire from the *d'Arsonval* coil is connected to this, the patient holds the other; a leather covered or felt blanket is spread over the mattress

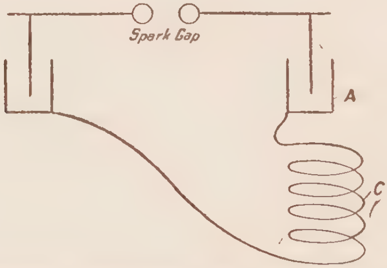


Fig. 20.—The above cut illustrates the large solenoid of d'Arsonval. This is large enough to place the patient inside of it, and when used in this way, it is termed auto-induction.

on which the patient is placed. (See Fig. 21, Auto-Condensation Couch.)

Instead of an auto-condensation couch *Piffard* makes use of an ordinary armchair, on the seat of which he places a cushion constructed in the following way: A circle 17 inches in diameter is cut out of whitewood one-half inch in thickness. Commencing at the center, a spiral of No. 3 (B. and S. gauge) aluminum wire is

wound with turns 2 inches apart between centers, until the circumference of the wood is reached, when the wire is turned to form a small loop. The wire is firmly attached to the wood by a sufficient number of double-pointed tacks. Three other circles are cut from the

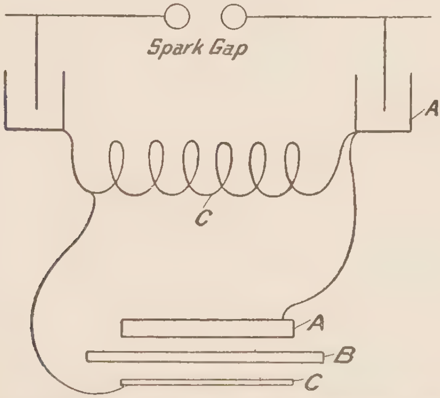


Fig. 21.—The third method of using the d'Arsonval current is shown above and is termed auto-condensation. "A" represents the patient connected with one terminal of the small solenoid of d'Arsonval. "B" represents a cushion of varying thickness, upon which the patient sits. "C" represents a metal plate under the cushion, and is connected with the other terminal of the small solenoid.

same wood, one-quarter inch in thickness, and glued together to prevent warping. This three-ply piece is then fastened to the other by dowels, with the wire between them. A circle of plumber's felt, an inch or so in thickness, is then placed on the thicker circle, and the whole covered with leather.

Brass balls two inches in diameter are fastened to the arms, and these balls are connected together by a light chain or wire running under the chair.

If the chair is to be used in connection with a coil, a condenser and a small solenoid, or *Piffard's* spiral is connected. A conducting-cord connects the outer foil of one of the jars to the loop in the cushion, the other cord connects the balls on the chair to the other jar.

Note. It is essential that there should be a proper relation between the size of the primary wire windings in the *Tesla* coil and the capacity of the condensers.

The intensifying electrode is really a resonator, and its weight being slight, it can as easily be handled as a vacuum tube; gives it a considerable advantage over the *Oudin*, especially as in its results it is of at least equal value. "The maximum of effect is produced by placing the patient without shoes upon some insulated surface attached to one wire of the high-frequency apparatus. The intensifying electrode is attached to the other wire and approached to a suitable distance from the patient. The effluve is painless and almost invisible unless the room

is darkened. When this is done, a heavy spray of fire is seen to pass from the electrode to the patient, spreading out brushlike in all directions as it touches him." (See Fig. 22.)

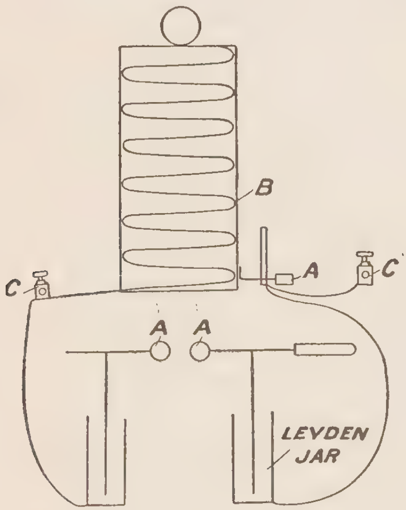
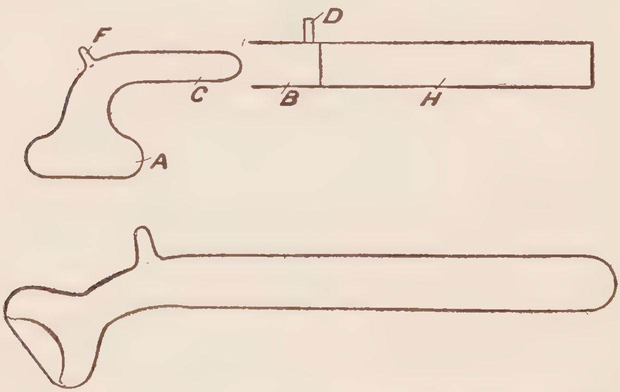


Fig. 22.—Shows a cylinder having a continuous winding on it, the lower end being connected to the outer coating of one Leyden jar. "A" represents a sliding contact on a post, which is connected with the outer coating of the other Leyden jar. As this contact is moved up or down, the spark from the top of the resonator is varied, and for each spark gap length between "A" and "A" the sliding contact can be varied so as to get a maximum spark from the top of the resonator.

Electrodes. These are usually hollow glass tubes exhausted to a low vacuum, and may be blown in any shape desired to fit the hollow cavities, such as the nares, the throat, the vagina, the rectum, or with a flat surface to be applied

to the surface of the body. They are fixed in an insulated handle, and a wire from one terminal is attached, the other terminal being connected to the patient by means of a wire and a brass handle, usually in the form of a ball or hollow cylinder.

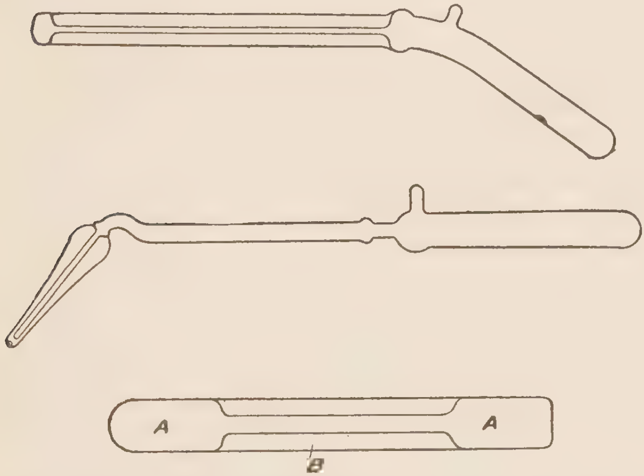


FIGS. 23 AND 24.—Illustrate the ordinary plain vacuum electrode.

In the use of high-frequency electrical currents, our efforts are continually directed to the production of a current of high voltage and diminished amperage. The apparatus can be attached both to the coil and to the static machine. (See Figs. 23 to 27 inclusive, Electrodes, various kinds.)

We will now trace our current from our coil or static machine, through our apparatus, to our

patient. Attaching the wires from the terminals of our static machine or coil, we carry these to the condensers. These are charged and discharged, the quantity of current and rapidity of discharge depending upon the amount of foil in



Figs. 25, 26 and 27.—Illustrate insulating vacuum electrodes. "A-A" being vacuum chambers joined together by a long, narrow tube which is surrounded by an extra glass tube "B" which prevents the current from jumping from the smaller tube to any tissue that may be in contact with the surrounding tube "B."

the condensers and the distance apart of our spark gap, also by the quantity of electricity evolved by the static machine or coil. The greater the distance apart of our spark gaps and the larger the quantity of foil, the greater the quantity of current in each discharge,

granted the initial energy remains the same in each case. The nearer our spark gaps are approached and the smaller the quantity of foil, the greater the rapidity of discharge and the smaller the quantity of the individual discharge. It will be seen that none of these factors can be taken by themselves in considering the result. The current is now carried by means of wires to the hyperstatic transformer or to the *Tesla* coil, entering the helix or primary at one end, and flowing out at the other back to the condenser. In so doing, it traverses the primary and sets up a rapid oscillation, thus stepping up our current once more and producing a higher frequency current. If we desire to use the *d'Arsonval* current, we do so by means of the wires attached to the helix, as already described. This is a current of high voltage and low amperage, but in comparison with the *Tesla* current, about to be described, is a current of higher amperage. (See Fig. 28.)

The Tesla Current. In flowing through the helix, this current sets up a further induced current in the secondary winding within the glass cylinder, a secondary superinduced upon a secondary or tertiary current, transforming it

into a current of higher voltage and diminished amperage. This current is taken off by means of the terminals, *i. e.*, the wire at either end of the secondary, and carried to the patient as the *Tesla* current. (See Fig. 18.)

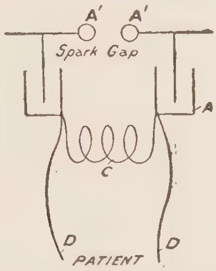


Fig. 28.—The above figure illustrates the essential parts necessary to obtain the d'Arsonval high-frequency current. Terminals marked "spark gap" are connected with a source of high voltage current, "A" represents a Leyden jar, "C" a coil of very heavy copper wire, connecting the outside of the Leyden jars together. The frequency of the current is dependent upon the following factors: First, amount of tin foil surface; second, length and size of coil which joins the outer coatings of the Leyden jars together. The number of times that a spark passes between "A" and "A" does not change the frequency of the current. The less tin foil used and the shorter and larger the wire which joins the jars together, the higher will be the frequency of the current. When the patient is connected with the terminals "D D," he receives what is known as the d'Arsonval shunt or derived high-frequency current.

As has already been said, the secondary current which we have taken from the *Rhumkorff* coil, in this case, becomes a primary current, in its turn inducing a secondary current in the secondary of the *Tesla* coil—in other words, a secondary superinduced upon a secondary current.

A point which we wish to emphasize and which must be borne in mind, is that the physiological effect of the *d'Arsonval* and the *Tesla* currents is entirely different. This will be described more fully later on.

There is a distinct difference between the high-frequency current derived from a coil and one from a static machine. The one from the coil is of higher amperage, but lower voltage.

CHAPTER V

X-RAY TUBES

The X-ray tube, in its original form, is nothing but the *Crookes* tube.

It consists simply of a glass tube, having a flat aluminum disc at one end and an aluminum wire sealed into a side projection. When the aluminum disc is connected with the negative of an X-ray coil and the other terminal with the positive, and the tube has been exhausted to the proper degree of vacuum, the cathode stream goes from the aluminum disc and strikes on the glass at the end of the tube. Where it then strikes is the source of the X-ray. (See Fig. 29.)

Various modifications have taken place in the form of the X-ray tube, until at the present time it has grown to be a rather elaborate affair. Its component parts are a globe (this globe varies greatly in size) joined at each end to cylindrical glass tubes sealed at one end. Through the larger of these runs an aluminum rod, insulated by glass, and terminating in a concave disc,

called the cathode. This does not project into, but is flush with the opening in the globe where the tube is attached. This cathode, or negative end, should always be a perfect segment of a circle, in order to properly converge the rays upon the anode. If a cathode is not perfect, which can readily be told from the manner in which it burns or discolors (an imperfect seg-

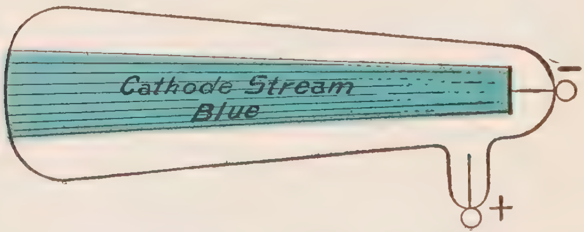


Fig. 29.—Illustrates the original Crookes tube, the X-ray being generated at the end of the tube where the cathode stream strikes the glass. It was from a tube of this type that the X-rays were first obtained. Owing to the many sources of the rays, the pictures were very indistinct.

ment of a circle showing a circular burn not directly in the center of the disc), the stream will not converge upon the center of the anode and the focus of the tube will be imperfect. This is a matter of less moment when the tube is to be used for treatment purposes, but when it is desired to use it for radiographic work, it is a vital imperfection. At the opposite pole of the globe, as already stated, a smaller cylindrical

tube is attached. Through this runs a metallic cylinder, usually of iron, beveled obliquely at the end, a piece of bronze affixed with a facing of platinum. This projects about half-way into the globe. Platinum is used as a facing for the anode, as it is the only metal so far used which will withstand the terrific bombardment of the rays, even platinum becoming red hot within a short time if too large a quantity of current is used. Above the anode, a shorter tube is let into the globe, with a metallic rod usually ending in a flat disc of aluminum set in the same direction as the principal anode. This is the accessory anode.

There are three types of tubes made at the present time. First is the non-adjustable, which is the simplest type. This consists of a glass globe, having a flat disc of platinum or some other metal faced with platinum placed near the center of the globe and at an angle of forty-five degrees to the long axis of the tube. In line with this is placed an aluminum cup, and when this cup is connected with the negative and the other disc with the positive, the cathode stream goes from the aluminum cup, strikes on the target and the X-ray is generated at this point. (See

Fig. 30.) If all of the cathode stream which strikes the target were transformed into X-rays, we would not see the beautiful green fluorescence which is common to the usual X-ray tube in operation. Unfortunately, at the present time, a perfect X-ray tube has not been made. Only a portion of the cathode stream is transformed into X-rays at the target. The rest of the cath-

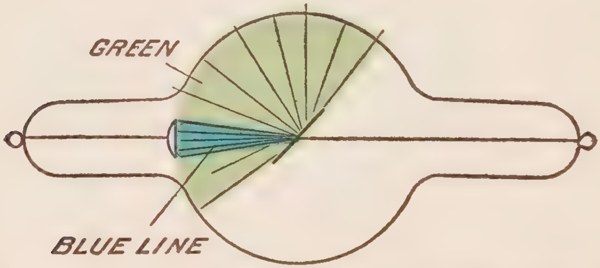


Fig. 30.—Above figure shows low resistance tube. Between the target and the cathode you will notice a heavy blue stream. The full hemisphere in front of the target shows green.

ode stream is reflected from the target, striking on the walls of the glass globe, and where it strikes, another X-ray is generated. These rays are what are called wild X-rays (see Fig. 31) and are very undesirable.

X-ray Tube That Can Be Regulated. This is of the same type as the one above described, but has in addition a small platinum tube sealed into it, having the end which is inside of the globe

open and the other end closed and soldered. When this platinum tube is heated to a bright red, it allows gas from the air to pass through the platinum into the globe, and in this way lowers the resistance inside of the tube. In using this regulator, care must be taken not to bring it to a white heat, also not to apply the heat at the

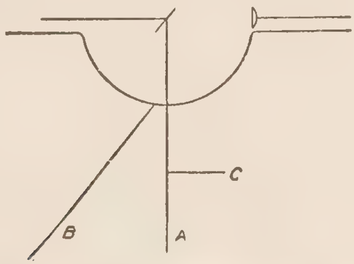


Fig. 31.—Above figure shows the three sources of rays from an X-ray tube. "A" represents the principal ray, which is generated at the target. "B" represents the wild X-ray, generated from the walls of the tube. "C" represents the secondary ray, which is generated whenever the principal or wild ray strikes an object. Rays "A" and "B" vary with the resistance of the tube. Ray "C" varies with the density of the substance struck by principal ray. "B" rays are generated from the entire hemisphere of the tube in front of the target.

extreme end of the tubing nor too close to the glass. Otherwise we are liable to either crack the glass or unsolder the end. (See Figs. 32 and 33 to 36, inclusive.)

A very common form of tube at present is known as the self-regulator. A short, L-shaped tube is let in at the top of the globe. This is filled with asbestos or some chemical which

gives off a gas when the electric current passes through. A wire is let in through the end of the tube. To this is attached a long wire with a

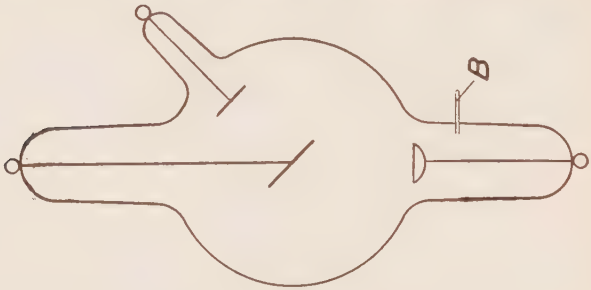


Fig. 32.—Regulating Tubes

The above illustrates a tube having a metal tube "B" sealed into it. When this metal tube is heated to a cherry red it allows gas to pass into the glass bulb, thus lowering its resistance. "B" can be heated with a match or an alcohol flame, great care being taken not to apply the heat too close to the glass, otherwise it is liable to crack.

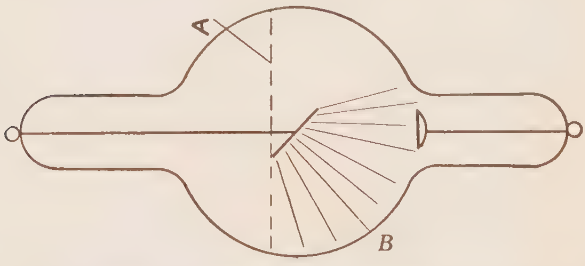


Fig. 33.—The above cut shows the tube connected up in the right way but showing considerable inverse. "A" represents a green ring which appears above the target. The glass in front of the target also shows green; an extra green spot also appears at "B."

flexible joint, so that it can be pushed down so as to come in contact with the negative wire or raised away from it. By passing the current

through this wire, a gas is given off from the chemical, which mingles with the gas in the globe, thus lowering its vacuum. (See Fig. 37, Regulators.)

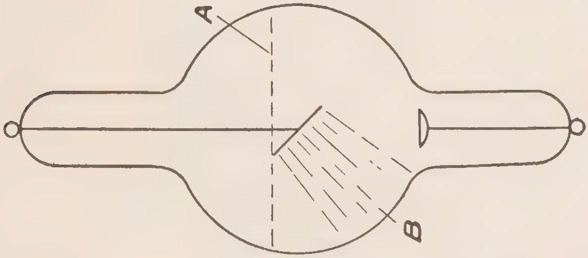


FIG. 34.—Above figure illustrates an X-ray tube connected up the wrong way. Above the target you will notice a number of green rings "A." The lower hemisphere is also filled with green rings, and at right angles to the surface of the target you will find an extra green spot "B." This is where the cathode stream strikes the glass bulb.

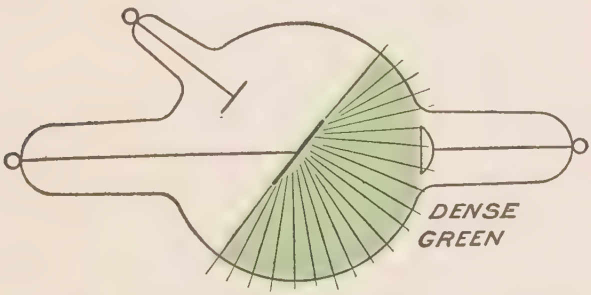


FIG. 35.—Above figure shows the tube connected in the proper way and operating satisfactorily. You notice that there is no green ring, and that there is no green spot, and that the full hemisphere in front of the target shows a brilliant green.

Special Tubes for Treatment Purposes

The one in most frequent use is designed by *Dr. Henry G. Piffard.* It consists of two heavy

lead glass bulbs connected together and having a projection from one directly in front of the target. This projection has a window made of

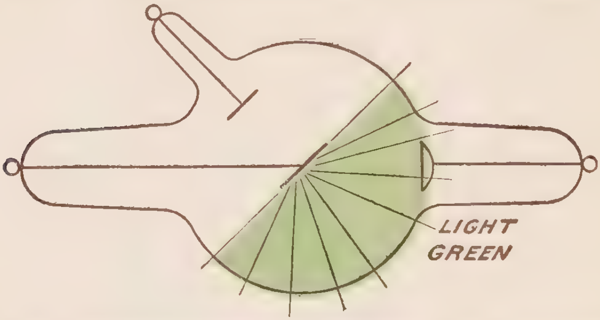


Fig. 36.—Above figure shows high resistance tube, full hemisphere in front of the target showing very light green, with numerous green spots and a tendency to discharge from the cords with which the tube is connected.

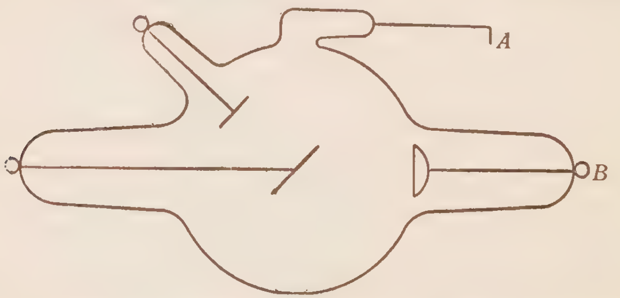


Fig. 37.—Represents a self-regulating X-ray tube. When adjusted for a certain parallel spark gap, if its resistance becomes higher than the parallel spark gap it was set for, the spark will pass between "A" and "B" so that the current is conducted into the small extension tube having a chemical which, when the electricity passes through it, gives off a gas which lowers the resistance of the tube. When using the tube as a pointer, as shown on Fig. 37, it is necessary to turn the current off and keep moving the pointer "A" a little closer or a little further away according to the desired regulation of the tube. When, however, the tube is connected as shown by Fig. 46, then the operator does not have to shut off the current, as the spark gap is adjusted by raising or lowering the rod "E" of the middle spark gap.

soda glass, which allows the X-ray to pass through it easily. The rest of the bulb, being of lead glass, does not permit the X-ray to pass through. There are lead glass shields made which fit on to the projection, so that the rays

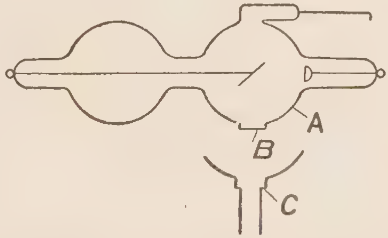


Fig. 38.—"A" represents a bulb of lead glass. "B" a window of soda glass which allows X-rays to be passed through it. "C" a lead glass shield which fits on to the projection of the main tube, thus confining the rays to an area equal to the opening at the end of "C." This tube was designed by Dr. H. G. Piffard, and is intended to protect the operator as well as the parts of the patient it is desired not to ray.

are confined entirely to the area to be treated. This tube is made self-regulating. (See Fig. 38.)

A modification of this is known as the Cornell tube, designed by *Dr. Albert Geyser*. It is essentially a very small *Piffard* tube, but is used in a different way. The soda glass window is kept in absolute contact with the part to be treated. (See Fig. 39.)

English Derma Tube. This is practically the original *Crookes* tube, having a handle at-

tached to it and a shield to regulate the area treated. This is also brought in contact with the part to be treated. The X-ray in this tube,

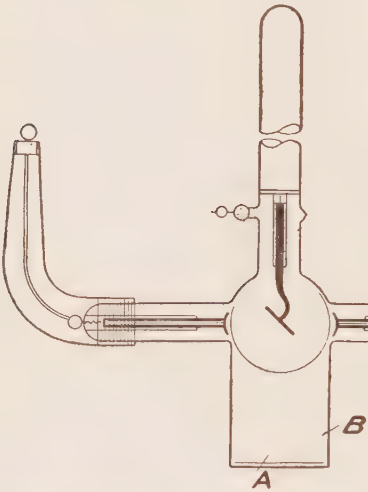


Fig. 39.—Represents a modification of the Piffard tube. It is known as the Cornell treatment tube. The main chamber "B" is made of lead glass. "A" is a soda glass window at the end which allows the X-rays to pass through it. This tube is very small and as used by Dr. Albert Geyser, the soda glass window "A" is to be kept in permanent contact with the part to be treated.

however, is generated at the wall of the tube in contact with the part to be treated. (See Fig. 40.)

Caldwell Tube. This is another modification of the original *Crookes* tube, and is intended for treating cavities. In place of the cathode stream striking on the glass, *Doctor Caldwell* had

a piece of platinum sealed inside of the tube, so that the cathode stream focusses on this target.

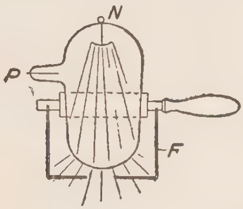


Fig. 40.—Represents the English Derma tube, it being practically a type of the original Crookes tube, the X-rays being generated at the closed end of the tube so that their penetration is very slight. "F" is a shield to cut off undesirable rays.

Owing to the heat generated, it has been found necessary to use an extra tube to cover this extension and the under space filled with water,

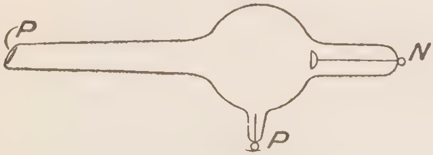


Fig. 41.—A modification of the Derma tube designed by Doctor Caldwell. The rays from this tube are much more penetrating than from the Derma tube, owing to the fact that the cathode stream strikes on a platinum plate at the end of the projection. This tube is intended particularly for treating cavities. Owing to it becoming very hot, however, a glass jacket containing water is required which reduces its efficiency very much.

so that it makes a rather inconvenient tube for practical use. (See Fig. 41.)

The efficiency of an X-ray tube depends upon the following factors:

(1) The cathode must be an absolute segment of a circle.

(2) The anode must be heavy, with a thick facing of platinum, and must be so placed that the converging cathode stream will be received upon the center of its beveled surface.

(3) The larger the globe, the greater the radiating surface and the less rapidly will the tube heat up.

(4) It is essential that there shall be no imperfections in the glass, and the annealing of the globe to the cathode and anode ends must be perfect.

(5) The vacuum in the tube itself. Most tubes, when they come to us, are of comparatively low vacuum, the tendency being for the vacuum to rise under proper usage. Tubes are denominated high or hard tubes and low or soft tubes, the terms referring to the degree of vacuum in the tube. Small tubes require less energy to excite them, are comparatively cheap, rich in cathode and rather poor in penetrating X-rays, and are suitable for treatment purposes up to four or five amperes in the primary of a

coil or with a static machine. Large tubes are much more expensive, but more durable, require a greater energy to excite them, are rich in X-rays, can be used for treatment purposes and are very efficient for radiographic work and fluoroscopic work where considerable penetration is required.

We will now trace the current from our static machine or coil to our X-ray tube. The current passes along the cathode, the stream converges upon the anode, part is transformed into X-rays and part is reflected, much as a billiard ball would be, against the wall of the globe, the best focus for our purpose of the rays being midway between the cathode and a point opposite the anode. In their reflection a part of the rays remain as cathode or negative rays and a part are changed into X or unknown rays, the number of rays which are changed depending, possibly, upon the degree of vacuum in the tube and the quantity of current used. The higher the vacuum up to a certain point and the quantity of current, the larger the number of penetrating X-rays.

Piffard says: In order to learn the "points" of a new tube and ascertain the means of ob-

taining its best efficiency, proceed as follows: Attach the tube to the coil with the cathode cord in position and an oscilloscope in series. Then attach the positive cord to the target terminal and note the behavior of the oscilloscope with the tube in action under various amperages. Next transfer the positive cord to the independent anode and again note the conditions of the oscilloscope. Third, connect the anode and target together and proceed as before. The valve is now introduced to correct inversion, and the milliamperemeter will indicate the efficiency under different amperages through the primary.

Properties of the Cathode and X-rays. Cathode rays are governed by the ordinary rules of light, being reflected and refracted as are ordinary light rays, bent from their course in passing to and from a dense to a rarer medium and penetrating substances with great difficulty, not going further than six millimeters below the surface of the skin. The X-ray is not amenable to the ordinary rules of light, is not reflected or refracted, passes in straight lines through all substances with a velocity proportional to their density, and consequently penetrates all the tissues of the body.

What the Color in a Tube Denotes. A purple color denotes a tube of very low vacuum, one rich in cathode rays, but with X-rays of low penetration. A yellow glow also denotes a low tube, but higher than the first. As the tube grows greener, the penetrating rays increase. An apple-green color denotes a tube of medium vacuum; an opalescent color, one of high vacuum; a tube in which little color is perceptible without darkening the room, a tube of very high vacuum.

In addition to the rays already described, there are many others of scientific but little practical interest to us as radiotherapists. We will mention, however, two of sufficient interest to require our attention.

Wild Rays. These are rays partaking of the properties of X-rays, which are given off from all parts of the wall of the tube. They are sometimes called aberrant rays, and while weak in character, in the aggregate, their effect is very considerable. It is well for the X-ray worker to remember this, as his dosage of the ray is cumulative.

After working for a considerable time about an X-ray tube, the quantity of these rays which

he has absorbed will, in the aggregate, produce a decided effect.

Secondary Rays. Every body that the X-ray encounters in its path gives out in all directions certain rays which *Sagnac* designates as secondary, to indicate that they are derived from the primary rays that issue from the tube. These rays in turn may give rise to tertiary rays. It has been further ascertained by *Sagnac* that these rays will affect a photographic plate.

Reversed Polarity in a Tube. When an X-ray tube is put in action and instead of the steady glow of color we find concentric rings of light flashing across the globe, we know that the current has been reversed in the tube. This is not apt to occur in a coil where the positive pole is always the same, but in certain static machines where the polarity often changes, it is well to bear this in mind. When this occurs, the current should be turned off, the tube taken from its holder and replaced in the opposite position. (See Fig. 34.)

Puncture in a Tube. When a tube, either through too long continued use or because the quantity of current behind the tube has been too great, becomes overheated, the glass melts

at its weakest point. The vacuum is then destroyed.

When a tube becomes so high that the path of least resistance for the current is around the glass of the globe, rather than from cathode to anode, the current seeks out some imperfection in the glass, and a puncture results. A punctured tube can readily be detected, as in place of the steady glow, we have a purple spark jumping between the cathode and anode. (See Fig. 42.)

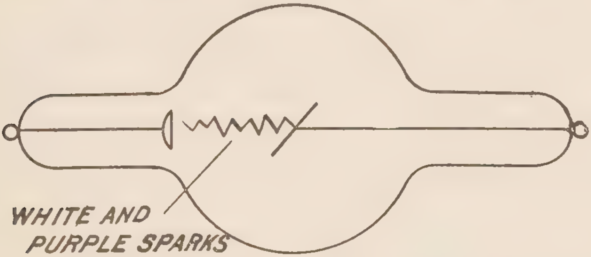


FIG. 42.—Above figure shows punctured tube. You will notice either sparks passing between the cathode and the target or you will notice a very heavy purple discharge with very fine white streaks through it.

When a tube which has been working satisfactorily begins to change in color from a green to a purplish hue, it is a sign that the vacuum is breaking down, and unless the current is immediately cut off, a puncture will result.

How to Use an X-ray Tube. As has before been mentioned, all tubes are of relatively low

vacuum when they reach us from the maker, and should be used at first for a very short time.

When the current is turned on in the tube, the anode tends to become hot, and throws off a gas. This mingles with the gas in the tube, the wall of the tube also becomes hot, and the occluded gas upon its inner wall also mingles with the gas in the tube, tending to reduce the vacuum. If, now, the tube is laid aside for twenty-four hours, this gas becomes occluded upon the inner wall of the tube, carrying with it some of the original gas in the tube, thus raising the vacuum. Through the constant repetition of this process, the tube becomes higher and higher, and, up to a certain point, more efficient.

When a tube has been used to a point where the vacuum is pretty thoroughly broken down, it can sometimes be restored by turning on the current for a few seconds and allowing the tube to thoroughly cool, and repeating this process. With care sometimes extending over a number of sessions, a tube can be brought to do very satisfactory work. When the vacuum of a tube is completely destroyed or a puncture has resulted, the manufacturers will pump out the tube once

more, or, in case of puncture, seal the puncture and then pump out.

In regulating a tube, *i. e.*, reducing the vacuum in a tube too high, care must be taken that the platinum tube used be not heated for too long a period, or, in the case of the self-regulator, the current be not turned on for too long a time, else the vacuum will be thoroughly broken down. Another method of reducing a tube which is quite satisfactory, is to place the tube in an oven on wooden racks, and bake it for an hour. This releases the occluded gas, and makes the tube once more serviceable. By reversing the polarity in a tube the vacuum can be somewhat altered.

Modus Operandi of the Self-Regulating Tube. Theoretically, the vacuum can be held at any desired point by the distances of the wire pointer from the cathode. Electricity seeks the path of least resistance, and when the resistance to the electric current is greater through the tube than through the air to the metallic pointer, the current will jump to the pointer, run along to the salt of metal or asbestos, etc., enclosed in the L-shaped tube, pour a certain volume of gas into the tube, and, the resistance now being less through the tube, the current passes through it.

When the resistance in the tube once more becomes greater than the resistance through the atmosphere, the process is repeated. By diminishing or increasing the distance between pointer and cathode, the tube is maintained at a certain degree of vacuum.

Water-Cooled Tubes. These are tubes having a water jacket inside the anode. The water is supposed to take up and radiate the heat, and so keep the tube cool. By means of a tube and syphon, cold water is sometimes passed through the jacket. Theoretically, these tubes are very attractive. Practically, they are very expensive. If a drop of water falls upon the globe, they are apt to puncture, they require constant attention and their life is short. We have not found them very useful. A large globe with a heavy anode will answer all purposes.

The Piffard Tube. The principle of the *Piffard* tube, already mentioned, is the prevention of a radiation of the rays except in the desired direction. This is accomplished by means of two lead glass globes joined together by means of a lead glass cylinder, so that the gas in the tubes may readily circulate. Two globes instead of one are used, as it has been found

impractical to blow one lead glass globe of sufficient thickness for our purpose. In the side of one of the lead glass globes is set the projecting window of soda glass. The anodes, cathode and regulators are attached in the usual way. The lead glass prevents the passage of the rays, which come out only through the soda glass window, upon which they are directed by the anode. These tubes are very useful and attractive for treatment work, as they require no shielding of the patient, the rays being directed against the part to be treated. These tubes are not very expensive, require only a small quantity of current, but are not very satisfactory for radiographic work. Their life, if properly used, is equal to that of the ordinary tube, but their vacuum readily breaks down if overheated by too prolonged use or the passage of too large a quantity of current.

Care of the X-ray Tube. In cold weather all tubes should be brought to body temperature by handling or a spirit lamp before being put in use. This prevents too rapid expansion of the tube. When a tube is overheated, it should be slowly cooled before being put in the rack. Otherwise, a puncture is liable to result. Tubes should be

changed often, and not required to do too great an amount of work at one session. It is wise to use all new tubes as treatment tubes, using a small quantity of current until they are properly qualified as radiographic tubes. No tube should be required to take more than one picture at a session, where the quantity of current required is great in order to produce penetration.

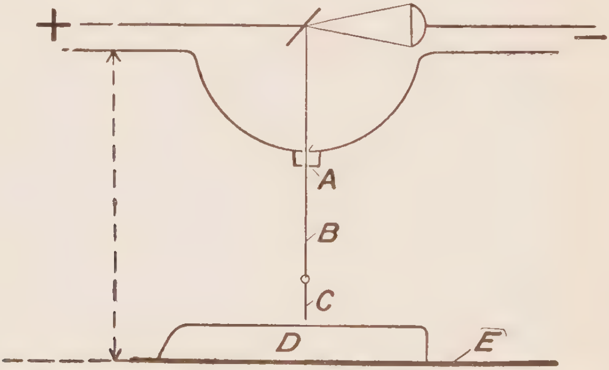


Fig. 43.—Shows the best position to place the plate in relation to the X-ray tube. "E" represents the X-ray plate, "D" the part to be radiographed, "A" represents a cork having a thread passed down through the center of it "B" and a pointer attached to the lower end "C." This pointer should come over the central portion of the X-ray plate.

General Laws Governing the Use of X-ray Tubes. For our purpose the principal ray from an X-ray tube is midway between the cathode and a point opposite the anode, but it must be remembered that rays are given off with less

intensity from all parts of the tube. (See Fig. 43.)

The patient should be placed opposite the principal ray, which should be as carefully adjusted as in aiming with a gun. This is a point more generally neglected by the beginner in radiotherapeutic work than any other point we have noticed. (See Figs. 44 and 45.)

The action of the soft X-ray produced by the cathode stream is only upon the surface of the

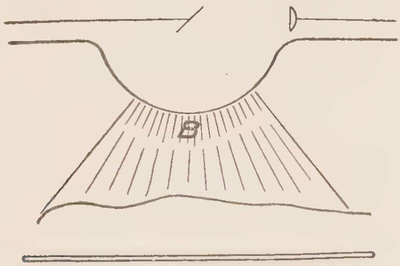


Fig. 44.—Illustrating the Necessity of a Diaphragm for Use When Making a Radiograph.

Above figure shows the wild rays from the entire front of the tube falling on the object to be radiographed and then on to the X-ray plate itself, tending to cause an indistinct plate.

skin, and is escharotic to a marked degree if the tube is placed too close. The action of the X-ray is not only upon the surface, but upon all tissues, and is effectual at greater distances than the cathode ray.

The strength of the rays is inversely propor-

tional to the square of the distance of the tube from the patient. Example: Let twelve inches' distance from the patient represent one. At six inches' distance we have four times the effect; at three inches' distance four times four or sixteen times; at one and one-half inches' distance sixteen times sixteen or 256 times. This is a point often lost sight of and is of extreme im-

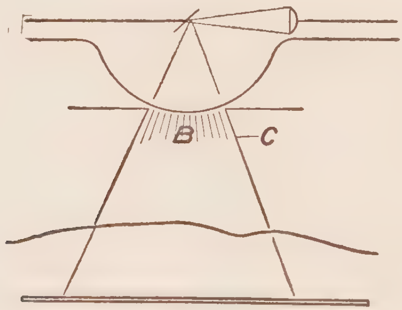


FIG. 45.—Above figure shows the same tube as Fig. 44, but having a diaphragm which cuts off all of the wild rays except the few which go through the opening, thus tending to make the negative very much more distinct. As the danger from the careless use of the X-ray is now well known and understood, every operator should take all necessary precautions to protect not only his patient, but himself. For treatment purposes, the lead glass tubes should be used, or the tube should be inclosed in a protecting shield. In addition to this, the operator should stand behind a shield lined with lead one-thirty-second of an inch in thickness.

portance. Its neglect is the cause of most accidents in burning.

What is Meant by the Inverse Current. When we close the switch of a coil, a current

flows from one pole to the other. This is the *make* current. The interrupter breaks the circuit, and a current, usually stronger, flows back. This is the *break* current. This alternation of the current occurs with every interruption of the circuit. In X-ray work, it is the break or *direct* current that we desire to utilize, and the make or *inverse* current that we desire to get rid of, as it is dangerous to the operator and interferes with the efficiency of the tube. This trouble is partly prevented by a valve tube.

CHAPTER VI

FLUOROSCOPY AND RADIOGRAPHY

Protection of Patient. All parts of our patient should be protected by lead foil at least one-thirty-second of an inch in thickness, excepting that portion which we desire to affect by means of the ray, and in case of a superficial neoplasm, a small section of surrounding tissue, in order to be sure that we are affecting the outlying cells. The apparatus should be placed in a separate room, and the operator should interpose a lead-lined shield or partition, fitted with a lead glass window, between himself and the tube.

Radiometers. There are a number of different kinds of radiometers which are used to measure the discharge or intensity of the ray, among others *Holtzknecht's* chromoradiometer and the pastilles of *Noire* and *Sabourand.* They are not in very general use, as they are all more or less inaccurate. With care and after a certain amount of experience, the operator can

detect, by means of the degree of penetration shown in the fluoroscope or by the color in the tube, the character of ray that he is using. We know that a so-called yellow tube is a soft one, that is, with few penetrating rays, and that a green one is rich in penetrating X-rays. (See Figs.) The method of *Dr. Carl Beck* is, however, probably the best for our purpose. This consists of a fluoroscope to which is affixed a skeleton hand. The character of the shadow thrown by the bones upon the screen shows the degree of penetration of the tube. If the bones are dark and only outlined, the tube is a low one; if the structure is clearly shown, then the tube is higher; but if the bones hardly cast a shadow, the light going through with but slight resistance, then the tube is very high. Of course, we shall find all sorts of gradations in the above.

A warning, which has been so often given that it is trite, is here repeated. Do not use your own hand in front of the fluoroscope to determine the degree of penetration of the tube. Use your patient's hand. Remember that you are getting a cumulative dose, which may result disastrously in the loss of hair, finger nails, skin,

and even in the production of epithelioma, where your patient's hand, being used but once, suffers no inconvenience. Still better is the skeleton hand affixed to the fluoroscope. This proves a very satisfactory substitute in showing definition.

Fluoroscopes. These are simply screens of cardboard, upon which the fluoroscent salt of some metal has been fixed. When they are interposed between the eye and the object to be studied, they produce a varying degree of transparency in the object. Fluoroscopes are of all sizes. For a careful study of large surfaces, such as the chest and abdominal cavity, large screens can be obtained. These are much more satisfactory than the small fluoroscope, as the entire subject can be studied without the shifting of the screen. (See Figs., Color of good or bad screen. Good, is light lemon; bad, is deep orange.)

Care of the Fluoroscope. The material of which the screen is made is very sensitive and easily spoiled by allowing dirt and dust to come in contact with it or by being placed near a hot radiator. The screen itself should be examined from time to time to notice whether it has begun

to deteriorate. The first indications are a change in color, beginning at the outer edges of the screen. When it is in good condition, it will be a light lemon green, almost the color of an X-ray tube. As it begins to gradually deteriorate, it begins to turn orange-colored. This change gradually takes place until it covers the entire screen. Although a screen in this condition can be used for ordinary work, yet it has lost over fifty per cent. of its sensitiveness. Often the X-ray tube is blamed when the fault lies entirely with the fluoroscope.

The fluoroscope should not be used unless absolutely necessary, owing to the danger to the operator, also to the danger of making a wrong diagnosis by an unskilled observer, this being especially true of impacted fractures. In order to make a satisfactory fluoroscopic examination, the room should be absolutely dark. The operator should be in the room eight or ten minutes before attempting to make the examination. In order to appreciate the advantage of the above method, the operator is requested to make an examination during the daytime and then examine the same case at night, when the advantage of the dark room and being in it for the ten

minutes will be appreciated. Until the operator makes this trial, it is impossible for him to appreciate its great advantage.

Points on Fluoroscopy. To make a satisfactory fluoroscopic examination, a steady current with a medium tube is desirable. Too great a quantity of current will break down the vacuum in the tube. It is desirable for the best work that a room painted dead black should be used. The light should be turned off for at least two or three minutes to allow the eye to adjust itself to the conditions before the current is turned into the tube, the patient previously having been placed before the tube in such a position that the rays will fall upon the point we desire to examine. No patient should be subjected to more than five minutes' exposure to the tube at one session, and, if possible, the individual idiosyncrasy of the patient to the ray should be established beforehand. It is quite possible to produce a severe burn in a susceptible person with a much shorter exposure. An important point often neglected is a failure to obtain the previous X-ray history of the patient. An example in point occurs to me. A specialist of this city was sued not long since by a patient for

producing a severe X-ray burn. At the trial it accidentally developed that she had been going to another X-ray man at the same time, thus receiving a double dose. Of course, this admission put an end to the trial.

Many conditions yield us clearer knowledge by means of fluoroscopy than by means of radiography. The size and condition of the heart, aneurisms, consolidations and cavities in the lungs, position of the diaphragm, the size of the liver, strictures of the œsophagus, the size of the stomach, the movements of the intestines, the condition of the sinuses of the head—all can be determined with greater accuracy by this means. The use of some salt of bismuth, mixed with food, such as apple sauce, to make a good bolus, is essential in determining stricture or diverticula of the œsophagus, size and movement of the stomach and of the intestines. This is fed to the patient in teaspoonful doses after the eye has accustomed itself to and made out the condition as accurately as possible.

The latest reports from *Hoffman's* clinic at Meburg, as well as scattered warnings from individual cases reported, show that the use of bismuth subnitrate in fluoroscopic work is not

without danger, especially in young children. He reports two cases of death resulting from this cause, the diagnosis being verified by autopsy as well as by the clinical findings. He suggests the use of the subcarbonate of bismuth as being much less toxic and equally efficient in casting a shadow.

In using the bismuth the operator should accustom himself to defining slight shadows. This is easily accomplished and subjects the patient to less risk of poisoning from the bismuth salt. A black shadow in the majority of cases is not essential to a proper appreciation of the condition.

As will readily be understood, upon the position of the patient in front of the screen depends the clearness and position of the image. We start with the patient standing or lying directly in front of the tube, and turn him from side to side gradually. By this means we determine the relative size and position of the shadows. It is well to remember that fluoroscopy and radiography is a study in the relative value of shadows, and that it requires special training in order to arrive at definite conclusions. It is often necessary to make several sittings in a difficult

case to determine accurately the meaning of the shadows presented to us.

Elaborate and special apparatus has been devised as an aid to fluoroscopy. It is, however, very expensive, and unless the student desires to go into this work very exhaustively, unnecessary.

Points on Radiography. The art of radiography is probably the most difficult thing with which we have to deal in our study of the X-ray, and is almost impossible to acquire by means of didactic teaching, practical experience in the art being essential to arrive at any sort of success.

Two methods are in use in taking radiographs. One consists of relatively short exposures with a very high tube and a large quantity of current, the second relatively long exposures with a small quantity of current. The first will give sharper outlines to our shadows. The second will show better the varying textures of our tissues.

The conditions confronting us with patient, tube, the machine for exciting the electric current and the plate, are all such varying factors, that to give any definite rules is almost an impossibility. We shall endeavor, however, to place the student in a position where he can figure out

for himself the varying relation between these factors, and so arrive, with some practice, at his own conclusion.

For the production of a radiograph, either the static machine or the coil can be used.

As it is essential that the quantity of current behind the tube shall be considerable, it is necessary, except in taking pictures where only slight penetration is required, to use either a large static machine, *i. e.*, one in which the quantity behind the discharge is considerable, or else the coil. A small static machine will give satisfactory results in taking pictures of children and of extremities. Where we have our choice, however, a twelve inch yellow flame induction coil is best for our purpose. With this, granting that our other factors are normal, pictures can be taken of any part of the body, after a certain amount of experience, which will reflect credit upon the operator.

The Interrupters. Where the coil is used, provided a small quantity of current only is required, as in extremities, either a mechanical or electrolytic interrupter (either the *Wehnelt* or *Caldwell*) can be used. For taking difficult pictures, the *Wehnelt* interrupter, with from

fifteen to twenty-five amperes in the primary, is best for our purpose.

The Tube. In the selection of a tube for radiographic work, we must look carefully to the focus. Unless our rays impinge upon the center of the anode, our picture will be blurred. This can be determined by the use of the fluoroscope, which should give not only good penetration, but absolute accuracy of definition. A high tube is best for our purpose. Indeed, it is essential to our success where deep pictures, such as hips, shoulders and stone in the kidney, are desired. The best distance for our tube is from fifteen to eighteen inches.

Fig. 44 illustrates most convenient position for placing X-ray tube when making a radiograph. The positive and negative ends of the tube should be equally distant from the plate. A point at right angles to the long axis of the tube and in front of the target should be marked on each individual tube. Then, when making a radiograph, a plumb line should be held in contact with this mark and the lower end directly over the center of the plate. A mark should then be made on the patient and two measurements made from this point to the two most

convenient bony landmarks, so that a view of the corresponding side can be easily made. The following suggestions will be found of great help to the beginner.

(1) Separate the secondary terminals of the X-ray coil eight inches and a half.

(2) Adjust the interrupter for the maximum discharge.

(3) Always have the target a uniform distance from the plate.

(4) Regulate the tube so that it just stops the spark from appearing between the secondary terminals of the coil.

(5) Always have lever of rheostat in same position.

(6) Simply vary the time of exposure for different parts.

(7) (And this is most important.) When making a picture of a joint, always have your tube in exactly the same relative position. If this is done, the picture of the same joint on different subjects will always have the same appearance. The advantage of this is, that if there is anything abnormal, you will easily notice it; whereas if you are not particular always to have your tube in exactly the same position, the ap-

pearance of the joint will vary accordingly as you change the position of the tube. This makes it very difficult for the beginner to make a diagnosis of dislocation. It is unfortunate that X-ray specialists have not adopted standard positions in which the tube should always be placed for each individual joint. As soon as this is done, the reading of X-ray plates of the various joints will be comparatively a simple matter; but until it is done, will be a difficult matter.

Regulation of Our Tube. It is essential to the success of a photograph that our self-regulating apparatus be accurately used. This can be determined by watching the ammeter in the primary and observing the color in our tube. A careful manipulation of this apparatus will often prevent the breaking down of the vacuum in the tube. (See Fig. 46, diagram and explanation of 3-wire system, *i. e.*, wire to regulator.)

When the vacuum begins to break, which will be noticed by the purpling of the color in the tube and also by a lower pitch in the sing of the spark gaps, the current should be instantly turned off. If this is not done, our vacuum will soon break down, making our tube useless. It should also be remembered that, after the vac-

uum begins to break, the tube is useless for further radiographic work at that sitting.

The Plates. There are a number of makes of plates suitable for radiographic work. Most

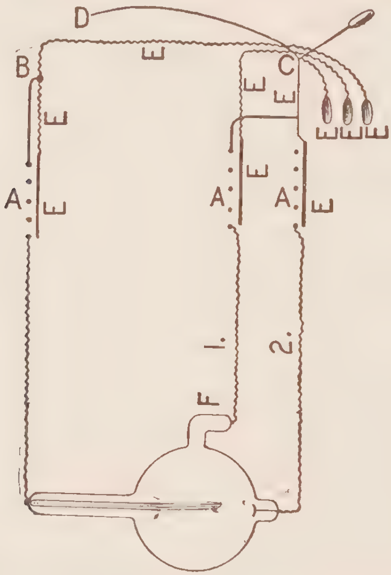


Fig. 46.—Illustrates 3 wire method of regulating X-Ray tube. A A A represents multiple spark gaps which are regulated by the 3 sliding rods E E E. The outer spark gaps, which are simply series gaps, should only be used when the tube is of a very low resistance or vacuum. The middle spark gap is used when the tube is of a very high resistance. As this gap is made shorter, it sends current through the extension tube "F" on the X-ray tube, which current sets free a gas inside of the main bulb, thus lowering the resistance. This spark gap is just the same as the one shown on Fig. 37 and represents the distance between A and B. When using the tube with a pointer, as shown on Fig. 37, it is necessary to turn the current off and keep moving the pointer A a little closer or a little further away according to the desired regulation of the tube. When, however, the tube is connected as shown by Fig. 46, the operator does not have to shut off the current, as the spark gap is adjusted by raising or lowering the rod E of the middle spark gap.

operators have an individual preference, but the essentials of a good plate are its freshness and its quickness. Where it is possible, it it wise for the operator to buy the plates in small quantities and place them in the envelopes himself in a dark room. These plates are very sensitive to light, and should be placed in a thick lead-lined box, if they are carried through the sunlight, even although wrapped in their outer envelopes, before being developed.

It goes without saying that the plates should not be exposed to the influence of the X-ray at any time except during the progress of the picture. However, operators often fail to realize the extent of the influence of the X-ray. I have personally had plates light-struck when placed in a heavy wooden box, separated from the tube by a wall, and twenty feet distant from the tube. When a picture is to be taken, the tube should be tried out, the patient placed in position, the focus determined, and then the plate brought in and placed in position. A detail worth observing is to place a coin in the upper right-hand corner of the plate. This will help us in determining the position of objects shown on the plate and often save us a good many puzzled moments.

The Patient. Children are easy radiographic subjects on account of the ease of penetration. In passing, we wish to call attention to the fact that the epiphyses of the various bones unite at varying periods in a child's life, some being delayed almost to maturity. We have frequently seen a fracture diagnosed by a good man, when the picture only showed the epiphysis united to the shaft by cartilage, the lesser density of the cartilage making it appear as though there were a separation. Children require relatively short exposures.

If we will keep in mind the law already enunciated—the X-ray penetrates all substances with a velocity proportional to their density—and remember that fat is penetrated most readily, connective tissue next readily, and then in order, cartilage, muscle, bone, blood, and last of all stone and metallic foreign bodies, we shall be able to determine, with our other factors normal, the proper exposure required in taking photographs of the different types of adults that come under our observation. Example: A fat man will be an easier subject for us than a muscular man of the same size. The muscles, containing much blood, tend to inhibit the rays. If we

wish to make a photograph of a foreign body, a longer exposure, to properly differentiate, will be in order.

Radiographs of Fractures and Foreign Bodies. We should never endeavor to diagnose a fracture or locate a foreign body by means of one radiograph. A little thought will show us how inaccurate will be a conclusion arrived at in this manner. Two or more photographs, in varying positions, should be taken, and the angle of incidence arrived at. This will give us the true location or position of the fracture or foreign body—kidney or bladder stone—differentiation of bone lesions, etc. We must emphasize the importance of negative diagnosis.

For those who are more expert in radiography somewhat elaborate apparatus has been devised, by means of which stereoscopic radiographs can be made. By following out the suggestions named above, however, accurate enough work for the average man can be done without resort to this procedure.

Personal Idiosyncrasy. We must bear in mind that the susceptibility of subjects to the X-ray varies greatly. Using large amperage, as we do in these cases, and with a high tube, seri-

ous burns may often result from relatively short exposures. This fact should be constantly in our mind. The patient should be warned, that, while it is not probable, it is quite possible that a burn of considerable severity may result, especially if the radiograph is that of a deep part, and the operator should properly protect himself, by a written release, if possible, from the patient. It has not been our misfortune, in several years, to burn a patient, but, especially with the beginner, too great care can not be exercised.

Diaphragms and Compressional Apparatus. Where our radiograph embodies some deep-seated structure, such as the kidney, or where it is desirable to limit the chest or abdominal expansion, various forms of compressional apparatus, to which are attached the tube, have been invented. It is hardly possible to take good radiographs in these locations without some such aid.

Ferrotype Sheets. These are sheets of thin, japanned iron, are commonly used, and can be obtained through any photographer. These are placed upon the table, the plate being placed upon them. Their object is to prevent the radia-

tion of the rays, and so give us a clearer outline to our picture. They are a very desirable aid to good work.

Development of X-ray Plates. The developer used with skiagraphs varies with the exposure and character of picture taken. All X-ray plates of deep structures should be rocked continuously. If they are laid in the bath without rocking, a mottling of the plate will result. This rocking must be continued in some cases, even for twenty minutes or half an hour in the case of a slow developer or where the exposure has not been properly timed. Attention to detail in development is nearly half the battle in obtaining good results.

Length of Exposure. It is impossible to formulate a rule which will help us very much as to the length of time required to take radiographs. As will be seen, it depends upon too many factors; the quantity of current we are using, condition of the tube and of the plates, and the size and density of our patient. The larger the quantity of current, the higher the tube, and the less the density of our patient, the shorter will be the exposure. With our factors reversed, the exposure becomes much longer.

Only individual experience will determine the ratio. Have a standard of spark gap length of the current in the primary circuit shown by the ammeter and of the distance of the tube to the plate. Then only the time factor will vary.

A note of warning should again be sounded relative to the protection of the operator in taking radiographs. We must remember that here all our factors of harm are at their highest potential. The operator should stand behind a heavy lead-lined screen, or by an arrangement of switches, at a considerable distance from the tube, or, better still, in another room, with a lead glass window through which he can observe the conditions. Evidences of disregard of this warning are constantly being brought to our attention, in the number of X-ray workers who are incapacitated by burns, atrophic skin and neurasthenia, to say nothing of sterility and cancer, as the result of their carelessness.

A practical point which will help us in ordering our X-ray tubes is the determination of what is called parallel spark gap length of tube. By this is meant the distance that the spark will jump across between the secondary terminals of the induction coil, when a tube is introduced

into the circuit attached in the ordinary manner. For example: If we wish a high tube, we will order one of six or eight inch parallel spark gap length; if a lower tube, one of four or five. This can be carried out indefinitely.

The Use of the Valve Tube. In radiography the use of a good valve tube is essential to take up the inverse discharge. This inverse current, if not eliminated, will fog our plate, spoiling what would otherwise be a good picture. No amount of care in regulating our other factors will save us if we neglect this. Of course, where the static machine is used, this warning is unnecessary.

For the student who desires fuller and more scientific information on the subjects just treated, the author would recommend *Dr. Carl Beck*, also an article by *Dr. Lewis Cole*, in the New York *Medical Journal*, published April 25, 1908.

PART II

CHAPTER VII

PHYSIOLOGICAL ACTION OF THE X-RAY AND OF STATIC, STATIC INDUCED AND HIGH-FREQUENCY CURRENTS

In taking up the study and the therapeutic application of our various electric currents and rays, it will be our aim to point out as clearly as possible the physiological action of these various currents and rays, and allow the student to make his own application to diseased conditions. Indeed, in the space we are able to devote to this work, it is impossible to go into all the details of the treatment of the various conditions in which these agents prove valuable. In addition, then, to the above, we shall give only such examples as will tend to blaze the path. The best electro-therapist is the one who treats each case not by rule of thumb, but with a proper regard to the varying conditions which arise, remembering that individual idiosyncra-

sies to the rays and currents are just as marked as idiosyncrasies toward drugs, and that a stated dose, which will always hold good, can no more be prescribed in the use of electrical agencies than in drugs. Furthermore, we desire to make no extravagant claims. Electricity and the X-ray is not a cure-all. Indeed, in many cases, even where it has therapeutic value, other agencies are preferable, both medical and surgical. On the other hand, there are certain diseased conditions in which, by its means, our results are incomparably better than by any other means at our disposal. It should be the aim of the electro-therapist to carefully separate the wheat from the chaff, and to bring the science to a new dignity by a careful choice in his treatment of cases, rather than, by extravagant claims, to make it the object of skepticism and ridicule, as is too often done.

In our study of the X-ray and high-frequency currents, it is well that we should bear in mind at the outset the character of the various currents with which we have to deal and what it is that we are endeavoring to do with those currents in order to produce the proper effect upon our tissues. With this end in view, as we have

said, an understanding of the physiological action is essential. There is probably nothing which a student endeavors to master in which he will find so great a variety of definitions or so wide a divergence of authorities, coupled with such confusing technical explanations, as in this realm of medicine. We shall endeavor to present, from a surgeon's view-point and in as few words as possible, an explanation which, in its practical aspects, will meet our needs.

The physiological action of the cathode stream in a low tube is merely that of sunlight intensified, producing, first, hyperemia, and if carried to its fullest extent, escharosis. It does not penetrate beyond six millimeters from the surface of the skin, consequently is valueless in treating the deeper structures of the body.

The X-ray in a high tube penetrates all substances with a velocity proportional to their density, travels in straight lines, has a selective action upon diseased tissue, and its effect is, first, to produce stimulation. Upon cell growth this stimulation produces a proliferation of cell elements by division of the nueclei and the formation of new cells. When this effect is intensified, it produces over-stimulation with destruction of

the cell through fatty degeneration or necrosis. Upon blood-vessels, this destruction of the intima or endothelial lining produces a curling up of the membrane, a plugging of the vessel with cells, an increase in fibrin, and finally an obliterating endarteritis. Upon connective tissue the stimulation produces an exaggerated adult type of connective tissue, *i. e.*, fibrous tissue, this by the growth of the cells changing them into fibers with obliteration of the neuclei. Its effect, then, upon epithelial tissue upon the surface of the body, is to produce a necrosis and slough of the tumor. Upon deep-seated epithelial growths its first effect alone is apparent, the end result being an increase in the growth of the tumor with the more rapid formation of metastases. Upon connective tissue growths, *i. e.*, first, sarcoma, its effect is to change the embryonal type of connective tissue into the adult type, transforming the sarcoma into a fibroma; secondly, by producing an obliterating endarteritis, to deprive the growth of a part of its nourishment, the end result being a fibroma with nests of sarcoma cells included within it. After a certain time these cells resume their growth, with a consequent recurrence of the sarcoma, which, however, reacts

to the ray as kindly as before. The weak point in our use of this agent in this class of cases is our inability to prevent the formation of metastases. The effect of the ray upon fibromata is simply to increase their growth through a proliferation of the fibers. Upon glandular tissue its final action, by over-stimulation, is to produce a death of the cell elements. This applies to all glandular tissue, adrenals, thymus, thyroid, lymphatics, liver, spleen, kidney, etc. Upon the leucocytes its action is first, by the division of the cells, to produce an increase, and then, by over-stimulation, a rapid diminution in their number. This applies in less measure to the red cells, producing anemia.

Toxic Action. By destruction of the cell elements and consequent liberation of nucleins, the X-ray produces a rapid accumulation of toxins. Unless this is carefully watched in the class of tissues which easily break down, a degree of auto-intoxication resulting fatally can readily occur.

X-ray burns. X-ray burns are probably produced by the action of the cathode stream producing X-rays at the surface of the tube, and to a less extent, of the penetrating X-rays upon the

tissues of the body. They develop very slowly. Three weeks from the time of the initial exposure is usually required for their appearance. They go on growing deeper by the destruction of tissue and obliterating endarteritis, are very painful, and can not be controlled by any known agent. The treatment of X-ray burns is extremely unsatisfactory. The use of a soothing ointment, orthoform in lanoline, in saturated solution, has yielded the best results, in our hands.

As the effect of the X-ray is to produce, first, an increase, and secondly, a diminution in the number of red cells, we should carefully look out for and treat the anemia resulting from our use of the ray.

Long continued exposure to the X-ray produces a neurasthenia of considerable extent. This should be remembered in treating our cases for considerable periods of time, and also by the X-ray worker. After a hard winter's work with considerable exposure, it is not infrequent to find some of our assistants so neurasthenic from the effect of the ray as to necessitate their temporary discontinuance of the work.

All X-ray workers must remember that the

effect of continual mild doses of X-ray is to produce a dryness of the skin through diminution of the glandular activity and in severe cases a keratosis, a falling out of the hair and brittleness of the nails. These by-effects are serious enough to be called to the careful attention of the operator. The continued, reckless use of the X-ray will produce atheroma of the arteries by increase of their fibrous elements, with its consequent effect upon the heart, kidneys and circulation.

The Action of the Static, the Static Induced, the Hyperstatic, the d'Arsonval, the Tesla and the Oudin Currents

The physiological action of the static current depends upon the manner of its use. We have the choice of three methods, as has already been stated in our chapter on static machines, namely: (1) The static bath. (2) The static spray. And (3) The static spark. These three differ considerably in their physiological effects, our idea of these effects and their efficiency depending somewhat upon the authority with which we agree. *Guilleminot* is probably as conservative as any.

The Static Bath. In the static bath the patient is insulated and placed in connection with one pole of the machine. The other pole may or may not be grounded. This produces: (1) An increase of frequency of the pulse, which remains for some time after treatment. (2) An increase in arterial tension. (3) A slight rise of the general temperature, it being more noticeable when the positive pole is used. There is also an increase of muscular force. (4) The excretion of urea is increased, indicating that oxidation of nitrogenous matter is very active. (5) There is an increase in the gastro-intestinal functions and a tendency toward drowsiness.

The Static Spray. This has a sedative action, calming painful sensation. It also appears to act as a stimulant to the tissues, probably by its action upon the trophic nerves.

The Static Spark. The effect of the static spark depends upon the size of the spark, consequently upon the electrode used and the distance of the electrode from the skin. It varies from a small pin prick to a heavy bombardment spark. It produces a considerable vaso-constriction with pallor of the skin, succeeded by a dilatation due to paralysis and relaxation of the

smaller vessels, with a resulting hyperemia. These effects are more marked with the positive than with the negative pole. The static spark has a more pronounced effect than is generally supposed, affecting even the deeper tissues. A rain of small sparks produces a sedative effect upon deep tissues.

High-Frequency Currents. The primary of the hyperstatic and the primary of the *Oudin* resonator produce the *d'Arsonval* current. The effect of the hyperstatic secondary current and its physiological action is exactly the same as that produced by the current from the secondary of the *Oudin* resonator and by the *Tesla*. In the book, unless otherwise stated, when we speak of using a high-frequency current and of applying it by means of vacuum electrodes, we refer to the form of current obtained by the secondary of the hyperstatic, *Tesla* or *Oudin* resonator, and when the simple term "high-frequency" current is used, we refer to the *d'Arsonval*.

An important physiological action of the hyperstatic, the d'Arsonval, the Tesla and the Oudin currents when applied locally, is to produce in varying degrees, depending upon the amount of irritation induced, what is very simi-

lar in its effects to the *Bier* congestion, that is, first, hyperemia. This hyperemia, or increased blood supply, produces an increase of leucocytosis, *i. e.*, phygocitic action; secondly, an absorption of plastic exudate; thirdly, an increased germicidal action of the blood at the part. An additional result is an analgesic action by obtunding the sensibility of the terminal nerve filaments, and, in the *d'Arsonval* current more especially, a fall of blood pressure by action upon the vaso-dilators and consequent enlargement of the venous radicals. The *d'Arsonval* and the hyperstatic currents, in addition to the above, produce greatly increased glandular activity, the former having a general application and acting as a tonic, increasing oxidation and the excretion of carbonic acid, while the latter is chiefly local in its effect. Some writers maintain that the high-frequency currents simply flow over the surface of the body without penetrating it, but others, such as *Piffard*, *Strong* and *Belot*, deny this, claiming a deep, as well as a superficial effect.

The Tesla Current is remarkable for the rapidity of its oscillation and its high potential, has little effect upon general metabolism, and its chief effect is that resulting from the hypere-

mia it induces. I have found it superior, both as an analgesic and curative agent, in that class of cases in which the *Bier* treatment has given such remarkable results.

The d'Arsonval and the wave current both affect metabolism, increasing it markedly, but in entirely different ways. The first is a high-frequency current. The second is not. If the electrodes are in contact with the skin in the *d'Arsonval,* there is no sensation. In the wave current there is vibration. The hair stands on end, and there is a feeling of stimulation and well-being. *Piffard* assumes that "the wave current acts through a sort of molecular vibration or cellular massage, while the *d'Arsonval* may act through the development of heat in the tissues.

In the hyperstatic spark we have, first, electric bombardment of the tissues with probable ironization; second, projection of metallic particles from the electrode, if of metal; third, ultra-violet rays; fourth, disassociation of the oxygen atoms and their rearrangement as ozone; fifth, destruction of bacteria."

The above facts indicate the physiological action of high-frequency currents, namely, stimu-

lating metabolism and exciting hypermetabolism. In diseased conditions, diminished metabolism results in auto-intoxication through failure of elimination. The high-frequency current goes far toward re-establishing a normal relation between the building up and tearing down within the body.

CHAPTER VIII

TREATMENT OF SKIN DISEASES BY THE X-RAY

In the treatment of skin diseases by means of the X-ray, we employ a somewhat different method from that described for other conditions. In the treatment of deep-seated conditions, a high tube, rich in penetrating X-rays, is essential to success. This is necessary in order to secure sufficient penetration to set up a reaction upon the tissues we desire to affect. In treating superficial conditions, however, this is unnecessary. Therefore, a low tube will answer our purpose in some cases as well as a high one. This tube has the advantage of being much cheaper. Not only the tube itself is less expensive, and, if used with a small quantity of current, lasts as long; but it is much easier on the machine, *i. e.*, the coil or static, and requires less current to energize. On the other hand, in order to obtain the maximum effect, we must place the tube closer

to our patient. Where our standard of distance in the high tube ranges from eight to twelve inches, our standard in the low will range from four to six. Or in a case in which for some reason we desire the maximum effect, an even shorter distance can be maintained, care being used to properly protect the surrounding tissues.

Acne

Acne vulgaris and acne indurata, treated by the X-ray, with careful attention to the diet and bowels, has yielded results, the *Tesla* current being used as an adjuvant. In the case of acne, however, it is wisest to use a low tube with care, and the treatment must be maintained until a rather slight erythema is produced, but stopping short of a first degree burn. It is remarkable how the bullæ disappear and even the scars whiten out, grow smooth, and the skin resumes its elasticity. Treatment is given according to the case and the susceptibility of the patient, from two to three times a week, from ten to fifteen minutes each treatment.

The *Tesla* current is given in the same manner as in chronic eczema, and may be alternated

with the X-ray or given after each individual treatment for five minutes.

Careful protection of the unaffected parts by means of lead foil must be maintained, or a lead glass shield or *Piffard* or *Cornell* tube used.

Especial care should be taken to protect the margin of the hair. We frequently find the hair coming out badly on parts that have been improperly protected even where no erythema has resulted from the treatment.

Schiff, *Belot*, *Hahn*, *Freund* and others report cases of the above condition treated successfully with the X-ray. In these cases the author prefers high-frequency currents as being more under our control and more physiological. If the X-ray is used, care should be taken never to produce more than a slight erythema. Treatments are best given twice a week for ten minutes, at a distance of from eight to twelve inches, taking into account the individual idiosyncrasy of our patient and remembering that thin-skinned blonds burn much more readily than brunettes. Medical treatment directed to proper elimination, of course, goes hand in hand with our treatment.

Alopecia

Kienbock treats alopecia with the X-ray, and reports some successful cases. He uses a high tube at a distance of eight inches. *Holzknecht* and *Williams* also report favorable results by the use of this agent. Here, however, the author again prefers the high-frequency currents, the *Tesla* preferably, as it is probably the hyperemia induced which is largely responsible for the results obtained. *Holzknecht* says that a patch of skin affected with alopecia will grow new hair after the treatment much more quickly than normal skin. In using the X-ray, care must be taken not to carry the treatment too far, or the reaction will produce the opposite condition from the desired one. Where we desire to increase the glandular activity of our hair follicles, the *d'Arsonval* may prove a preferable current in these cases to the *Tesla.*

Acne Keloid

In this rare condition, which has proven extremely resistant to all other forms of treatment, the X-ray has yielded a cure in our hands in the three cases we have had under

treatment. It is necessary to carry our erythema, however, to a first degree burn to obtain this result. The mode of operation and the rules governing it are the same as in keloid. The tissue must be entirely destroyed to get a good result. We must remember, however, that the full effect of the ray is sometimes long delayed in its appearance and that nothing will stop the progress of a burn, once it has started. We should, therefore, proceed with caution, stopping our treatment from time to time to observe the effect obtained.

The treatment is, at best, quite painful, and nothing has as yet been suggested which will in any great measure relieve an X-ray burn. We therefore destroy a small area at a time and wait for healing before proceeding to our next area. Protection with heavy lead foil is desirable for the surrounding tissue.

Carbuncle

The treatment of carbuncle by the X-ray has proved very effectual. Either a hard or soft tube can be used. Five minutes' treatment, repeated at the end of three days if

necrosis has not already begun, gives very satisfactory results. The pain diminishes very rapidly after the first treatment, and is coincident with a softening of the mass. The slough resulting is very considerable, and the operator is earnestly warned against over-treatment. As a rule, enormous slough is apt to occur if treatment is carried too far. Careful protection to surrounding tissues is indicated.

Depilatory

As a depilatory, the X-ray is undoubtedly a success, but in order to obtain the result desired, two, or sometimes three series of treatments are required before the hair follicles are entirely killed. We must not forget, however, that in killing the hair follicles, we are also producing atonic changes upon all the skin and subjacent structures, effects which may prove more serious to our patient than the initial condition.

Epilepsy

Several authorities have reported favorable results from the use of the X-ray in this condition, a high tube being used at a distance

of twelve inches, and directed over the caput and various portions of the spine. In a series of six cases reported by me in 1905–6, I expressed myself as encouraged to believe that, in the X-ray, we had an agent that would favorably affect this condition. Later reports from these same cases, as well as observation in others, have convinced me that our results were probably accidental. My present opinion is that except as a last resort in desperate cases, this treatment is not justified.

Chronic Eczema

In chronic eczema, the use of the X-ray, alternating with the *d'Arsonval* or *Tesla* current, has given us favorable results in about sixty per cent. of our cases. Acute eczema should never be treated by the X-ray. A high or low tube can be used in these cases as desired, the amount of stimulation depending upon the type of the disease and varying with the progress of the case.

The *Tesla* or *d'Arsonval* currents have yielded us very favorable results. A short spark gap length should be used in the beginning, the bom-

bardment being gradually increased in severity as the patient grows used to the current. This I consider preferable to the X-ray.

A flat, glass electrode is used, the current applied for five or ten minutes each day to twice a week. Stimulating salves can be used as an adjuvant if desired. Appropriate medical treatment is not contraindicated.

Recurrences are liable and should be treated accordingly.

Favus

The treatment of favus may be undertaken with either the X-ray or high-frequency current. Some observers, notably *Belot* and *Freund*, report very satisfactory results. The treatment in these cases must be carried further than in other skin conditions. A beginning erythema must be produced which must not, however, go on to a burn. All of the hairs must be removed with forceps as they loosen. The tube is placed ten or twelve inches from the patient. The scalp must be kept thoroughly aseptic by dilute tincture of iodine or other antiseptics. Relapses occur, due to improper epilation. After the reaction has ceased, massage of

the scalp should be thoroughly done. The new growth of hair is usually perfectly healthy.

The Use of the X-ray in Hysteria

Kahane, of Vienna, reports some peculiar reactions in patients afflicted with hysteria. Whereas in most diseases accompanied by pain and itching, the use of the X-ray and high-frequency currents has a markedly sedative effect, in every case of hysteria treated these conditions were immediately aggravated, the patients complaining of disagreeable sensations in their limbs and the entire nervous system seeming to be upset. *Guilleminot*, however, claims to have cured hysterical aphonia by means of static sparks over the region of the larynx.

Herpes Zoster

Williams and *Belot* report cases treated by the X-ray, but their results are not very convincing. With the high-frequency currents the author has had fairly satisfactory results in aborting this disease and relieving the intense pain for a period of from three to sixteen hours after application. A curious fact noted

in nearly all cases was a considerable augmentation of pain, beginning shortly after treatment and gradually subsiding in the course of an hour or so. Either the *d'Arsonval* or *Tesla* current can be used, treatment lasting for ten minutes and occurring each day. The period of the disease is by this means shortened fully one half. Appropriate medical remedies directed to the cause of the condition are indicated.

Hyperidrosis

Pusey has had excellent results in the treatment of this condition from the use of the X-ray. The author has had no personal experience with these cases.

Keloid

In the treatment of keloid, we have, in the X-ray at our command, the only efficient treatment. The treatment of keloid, however, differs from that of almost any other condition, it being necessary for us to burn out the keloid tissue. As the burn resulting is very painful, it is advisable that we expose only a small portion, from one to two inches square, at a time, waiting

for this to heal before resuming our treatment. In a large keloid, this makes a very tedious, painful and prolonged procedure. The tube used should be a low one, rich in burning rays, as the escharotic effect is largely desired. The patient should be carefully protected with heavy lead foil, with an opening the size of the burn desired. The tube should be placed very close, even in some cases within an inch and a half of the tissue. To prevent the uncomfortable effect of the induced current upon the patient's skin, the lead foil should be lined with some thick, non-conducting material. After the production of a thorough burn, orthoform and lanoline should be employed as a dressing, and the patient encouraged by the statement that, when healing takes place, the keloid will have disappeared, being replaced by a smooth, pinkish scar, level with the surrounding tissue, which will rapidly blanch, until the scar will become imperceptible. In small keloids, this is an ideal treatment.

Leprosy

The use of the X-ray is now being tried in cases of leprosy by several operators. Re-

ports, so far, are favorable in cases which have come under observation in the early stages. It is yet, however, too early to prognosticate the results. *Scholtz*, on examination of the lepra lesions after X-ray treatment, found the infiltrated areas less marked, the bacilli granular in appearance, but not diminished in number. However, some remarkable results have lately been reported from the Hawaiian Islands and also from the Leper Hospital in Louisiana, which should, at least, encourage us to proceed in our experiments in these unfortunate cases.

Lupus Vulgaris

The treatment of lupus vulgaris is much like that of sycosis. In both these lesions care should be taken not to proceed beyond a slight erythema. A high tube at an increased distance gives us equally good, if not better, results than a low tube, but is, of course, more expensive. Where the lesion is extensive, as, for example, where a considerable portion of the face is affected, protection can be dispensed with. We emphasize the advice given in all skin conditions. Do not carry treatment to a

point beyond a slight erythema. The results obtained by X-ray are very good and compare favorably with those where the *Finsten* ray is the agent used.

Mycosis

Guilleminot is favorably impressed with the use of the X-ray in these cases. A high tube should be used. The itching is relieved at once, and very good end results have been obtained. The treatment is much the same as in sycosis.

Psoriasis

In the treatment of psoriasis we have, according to some authors, in the X-ray a very satisfactory agent for the treatment of a very chronic condition. A high tube must be used at a distance of twelve to eighteen inches, the radiance being directed successively over various portions of the body. The treatment should occupy about half an hour and be repeated twice a week. The condition is very chronic, and the operator should not be discouraged if improvement is slow.

Of course protection must be dispensed with

in this class of cases, and it is important that we should use exceeding care not to even approach to an erythema during our treatment. It is wise to begin our treatment at the greater distance and bring the tube nearer after a sufficient time has elapsed to prove the tolerance of the patient.

It should be remembered that psoriasis is the local expression of a systemic condition, and general treatment accordingly should go hand in hand with the X-ray.

The author personally prefers the *Tesla* current in this condition, applied by means of a vacuum glass electrode to the affected areas.

Seborrhea

As the effect of the X-ray upon the skin is to produce a destruction of its glands, it follows as a natural sequence, that, in this agent, we have an ideal treatment for seborrhea. Either a low or high tube can be used, care being taken not to continue the treatment too long, remembering that the action of our ray goes on for a considerable time after the cessation of treatment. A high tube best answers our purpose, a distance from nine to fifteen inches.

Treatment is given two or three times a week for from ten to fifteen minutes at each treatment.

Sycosis

Sycosis reacts very favorably to the X-ray. A low tube is used at a distance of six inches, the surrounding parts being carefully protected with lead foil. The treatments which consist of exposures for fifteen minutes twice or thrice a week, will usually result in the disappearance of the lesion in from six weeks to four or five months. It is well to bear in mind, however, that this condition is very liable to recur. The patient should be warned to return for treatment at the first sign of a returning lesion.

Trachoma

In intractable trachoma, cases where even operation has failed to result in a cure, and in those milder ones where the patient refuses surgical interference, the use of the X-ray has given us rather remarkable results. A high tube is used for this purpose. The patient is protected by a lead-covered cap and visor, through which holes are cut for the eyes. This cap and visor

should be lined with heavy cloth to prevent the disagreeable effects of the induced current. The patient holds the lids pulled down or up with his hands beneath the visor. The distance varies from six to nine inches, and the number of exposures from two to three a week. In several cases sent us by oculists, after the failure or curetting to give relief, we have been able to effect a cure.

Most cases recur, and an additional course of treatment is often required after an interval to obtain complete relief.

The X-ray has no injurious effect upon the optic nerve when given in therapeutic doses, and consequently can be given without fear in conditions about the eye.

Xeroderma

Jamison and *Allen* each report a successful case treated by means of the X-ray. This disease is very resistant, according to these authors, and requires a large number of exposures. In *Jamison's* case, eighty-four treatments were required to produce a favorable result. The author has had no personal experience with this condition.

CHAPTER IX

TREATMENT OF DEEP-SEATED CONDITIONS BY MEANS OF THE X-RAY. TREATMENT OF CARCINOMA AND EPITHELIOMA

THE treatment of carcinoma naturally divides itself, first, into the treatment of superficial carcinoma or epithelioma; secondly, of deep-seated carcinoma.

Epithelioma

There are no class of cases amenable to the X-ray that have yielded such brilliant results as those of superficial epithelioma. About ninety per cent. of these cases, in which the growth is confined to the surface of the body, *i. e.*, without metastases or glandular enlargement, can be cured by this means.

Where, however, glandular involvement has occurred, unless the glands are very near the surface of the body, the chance of a successful issue is very small. This conclusion has been arrived at after the treatment of a large number of cases extending over a series of years, and in

spite of the opinion expressed by some authorities. In about ten per cent. of cases, especially growths occurring in old people and in which the growth contains considerable numbers of nests of pearl cells, *i. e.*, keratoses, the X-ray, while it causes destruction of the growth, fails to prevent its almost immediate recurrence. In the treatment of epithelioma the operator should not be discouraged if his patient fails to react easily, but, with patience and a suitable dosage, he can rest assured of the total disappearance of his growth and of a resulting smooth white cicatrix. In this class of cases we have the choice of a low tube, or a high tube, one rich in penetrating X-rays. As the growth to be treated is on or near the surface of the skin, and as the low tube is efficient in these localities, and as, moreover, the energy or quantity of current required to excite such a tube is much less and the consequent expenditure less, the low tube will probably be preferred.

In treating a case of this sort, the patient should be thoroughly protected, leaving exposed the growth and about one inch of sound, surrounding tissue. This is for the purpose of eliminating any wandering cancer cells, which

may be present in apparently healthy tissue. The tube should be focussed directly upon the tumor. The distance of the tube from the patient depends somewhat upon the tube we are using—with a low tube, a short distance, an inch and a half to six inches; with a high tube, sometimes as great a distance as nine inches. If it is our desire to rapidly affect the growth, the tube will be placed a short distance from the patient, remembering that in this way we will probably get the escharotic effect with the production of a considerable burn. We must warn the operator not to produce too deep a burn, as in such cases an ugly scar will result. In the average case, possibly six inches will be the ideal initial distance, the tube at a later date being placed closer to, or drawn farther away from, the tumor, depending upon the idiosyncrasy of the patient.

We have two methods of treatment at our disposal. The first consists of giving huge doses, fairly overwhelming the tumor, using twenty to thirty-five minutes at each exposure, the exposures being relatively far apart. This method is not recommended by the author. The other method consists of starting with ten minutes'

exposure two or three times a week, increasing the length of exposures and decreasing the distance of the tube from the tumor if the growth proves resistant to treatment. Do not be discouraged if no result is apparent, even at the end of three months' exposure. When the tumor begins to react, the destruction will be rapid.

Deep-Seated Carcinoma

In our opinion, the only class of cases in which the X-ray is justifiable, are those of a thoroughly inoperable character where an alleviation of pain occurs after the use of the ray. This happens in about eighty per cent. of cases, and if the result at which we aim is merely euthanasia, this treatment is preferable to opium or other analgesics.

We must prepare ourselves, however, for the more rapid occurrence of metastases and the earlier death of our patient. In about twenty per cent. of cases, the pain is increased after the treatments. Where this occurs, the X-ray is inadvisable. The use of the X-ray in any primary, deep-seated carcinoma of the operable stage, is, in our judgment, unjustifiable. As

will be seen by reference to its physiological action, the ray penetrates with a velocity proportional to the density of the tissue. Its first effect is to produce, by stimulation, an increased growth; secondly, by overstimulation, a death of the cell elements, and, by the production also of an obliterating endarteritis, the death of the tumor. When, therefore, we are able to produce this secondary effect, the ray is efficient. Where only the first effect can be produced, we are simply increasing our tumor and adding to the danger of metastases. In all the cases that have come under our observation in the last ten years, treated both by ourselves and by others (and this numbers nearly two hundred cases), death has been the inevitable result of the treatment of deep-seated carcinoma of primary origin by the X-ray, only the first or stimulating effect being apparent. In a number of cases first rayed and afterward operated upon by ourselves, in which careful and abundant sections have been made and studied, no efficient effect has been found in the tumor. The examination of the enlarged glands has resulted in finding two sorts of glands, one the seat of malignant degeneration. On these glands the rays had no

effect. In the second class, where the glands were found affected with non-malignant inflammation, a reduction in size or elimination of the glandular structure had taken place. This last is in line with the results of all observers; that is, that glandular tissue, not the seat of malignant degeneration, can be entirely destroyed by the application of the ray.

Treatment of Enlarged Glands

By reference to the physiological action of the X-ray, we learn that it produces a destruction of all glandular tissue not the seat of malignant degeneration. By the application of this principle to enlarged glands wherever situated in the body, we arrive at very satisfactory results.

Leukemia and Pseudo-Leukemia

The early statistics obtained from the treatment of these conditions by the X-ray, made us very hopeful that, by this method of treatment, we should be able to obtain results more brilliant than by any other therapeutic measure. It is not at all difficult to produce a rapid diminution in size of the affected glands, including spleen and liver, with a

corresponding reduction in the number of white blood cells, even to a normal ratio; but unfortunately, most of these patients finally died, in from one to two years, with a normal number of white blood cells. The most plausible solution of this perplexing result at the present time, seems to be that the rapid destruction of tissue has resulted in the liberation of toxins, which, by their effect upon the kidneys, heart and other organs, have produced death. Enough data has been gained, however, to make it seem worth while to continue our treatment of these patients, being careful to make frequent examinations of the blood, urine and feces, and to be less strenuous in our treatment. A high tube should be used, a distance of nine to twelve inches, the ends of the long bones, the spleen, liver and sternum should be exposed alternately, and the treatments should be regulated from two a week to one in two weeks, depending upon the results of the examination referred to above.

Grawitz reports considerable success in the treatment of leukemias during the last three years, that is, since he has utilized the X-rays extensively for this purpose. Ten of the twenty-six patients suffering from myelogenous leu-

kemia recovered under treatment with the rays, the spleen diminishing to normal size, and the blood assuming its usual picture. Three of the ten had relapses, but a second course of treatment again proved efficacious in relieving them. Only one patient with lymphatic leukemia was cured of the disease.

Syphilitic Glandular Enlargement

Syphilitic glandular enlargement should not be subjected to the X-ray, as its results will be a rapid breaking down of the tissue, with a nasty scar. The same rule as in surgery applies to all syphilitic manifestations. Medical means are preferable.

Goiter

The efficiency of the X-ray in goiter depends upon the type of the disease with which we have to deal. Where our goiter consists of an increase of the stroma of the gland, the X-ray, by increasing the quantity of fibrous tissue, will only produce an enlargement. Where our tumor is the result of an increase in colloid material, no effect will be produced. In those cases in which we have a true hyperplasia of the

glandular elements, the X-ray, by producing a destruction of these elements and an increase in the growth of our fibrous tissue, will produce a marked diminution in the size of the tumor and an amelioration of the symptoms resulting from hyper-thryoidism. In addition to this action, the sedative effect of the X-ray is apparent in many cases. Indeed, in many cases, the ray acts almost as a soporific, and the pulse rate falls from ten to thirty beats during or immediately after the treatment.

Details of Treatment. It is best, although not necessary, to place the patient upon a couch, and thoroughly protect all parts with lead foil, except the gland. A high tube may be used at a distance of from nine to twelve inches, the exposures varying from one to three a week, depending upon the reaction of the patient. Of thirteen cases treated by ourselves in the last six years, five have been unimproved, four greatly improved, and four remain to the present time without symptoms, *i. e.*, apparently cured. The *d'Arsonval* high-frequency current is often a valuable adjuvant to this treatment, used over the cervical sympathetic for fifteen minutes, alternating with the X-ray.

Schwarz reports from *Holzknecht's* laboratory at Vienna forty cases of exopthalmic goiter in which *Roentgen* treatment was used during the last three years. The rays are applied to the thyroid. He filters the rays through leather, window glass or tin foil, and exposes the thyroid from different sides, so that a given part of the skin is exposed only at intervals of six weeks. The exposures are made every two weeks. The nervous and especially the heart symptoms were promptly and permanently improved. The exopthalmus was improved in fifteen patients, the goiter retrogressed in eight, twenty-six gained in weight, and thirty-six had the pulse reduced, while the benefit on the nervous system was marked in all. One patient gained forty-eight pounds with no change in diet.

To *Doctor Pfahler*, of Philadelphia, is probably due the credit of suggesting leather, tin and silver as a filter for the X-ray. By this means we are enabled, in considerable measure, to prevent the distressing X-ray erythema, which too often in the past followed prolonged treatment.

Prostatitis

Where we have to deal with a true hypertrophy of our glandular elements in the prostate, the use of the X-ray is strongly indicated. A reduction in the size of the gland, through destruction of the epithelium, the obliterating endarteritis and the increase in the fibrous elements, results in a greatly diminished mass. Where our increase, however, is due to fibrous tissue, not only can no favorable result be looked for, but an actual increase will result from this treatment. The treatment consists of the use of a high tube at a distance of nine to twelve inches, applied two or three times a week, the perineum being exposed and all other parts carefully protected with lead foil.

The treatment should not be carried too far, as we must remember that an increased growth of connective tissue goes on hand in hand with the process mentioned above, and the end result may be an increase in the size of the gland from this means.

Treatment of Sarcoma

In the treatment of sarcoma, we are dealing with an entirely different histological or patho-

logical type of tissue. The sarcoma resembles embryonal connective tissue, being rich in cells of round or spindle shape with a loose reticulum of fibers. Coming now to the application of our principle already mentioned, that the effect of the ray is to stimulate cell growth, the effect upon sarcoma will naturally be the production of an adult type of connective tissue, that is, one rich in fibers, packed closely together, with few cells. The stimulation effected by the ray, changes over the embryonal type of connective tissue into the adult type, changing a sarcoma into a fibroma. It also, by the production of an obliterating endarteritis, deprives the growth of a certain amount of its nourishment. The contraction of the growth also tends to reduce its vascularity, the end product being a fibroma with an inclusion of nests of sarcoma cells within its mass. In determining whether we shall treat a sarcoma with the X-ray, the operability of the tumor comes into question. In these cases, the author strongly recommends its elimination by means of surgical procedure in all possible cases. Where we have an inoperable sarcoma, however, we are justified in the use of the ray. We have been fortunate in being able

to cause a disappearance of about forty per cent. of these tumors.

Recurrence. It is, unfortunately, true that nearly all these cases recur after a time. The nests of cells included in the mass take on renewed energy, and it is essential that a second series of treatments be instituted. These recurrences react, however, just as kindly, in many cases, as the initial tumor. We have personally rayed a number of second and third recurrences with satisfactory results, and in one case we have been compelled to treat the tumor for the fifth time. This case is now of five years' standing, and at the present time shows no sign of further recurrence. It must be remembered of these cases that we never get a complete disappearance of our mass. A fibroma of an extent proportional to the original tumor always remains. Where we can do so, it is advisable, after raying these cases, to enucleate the remaining mass.

It must also be borne in mind that the danger of metastases is always present while our patient is undergoing treatment. In melanotic sarcoma, this is a very grave danger; in osteosarcoma, somewhat less; and in spindle-celled,

round-celled and fibrosarcoma, proportionately less. Osteosarcoma is more resistant to the action of the ray than any other type with which we have had to deal.

Details of Treatment. If we are dealing with a deep-seated tumor, we must select a tube with the greatest penetration possible, *i. e.*, a high tube with a large number of penetrating X-rays. The patient should be protected except for the parts to be rayed. As it is essential, owing to the location of the growth, that a larger area should be exposed, our protection is necessarily less complete than in superficial conditions. The tube is best placed at a distance of nine to twelve inches in the beginning, the exposures starting with ten minutes' application two or three times a week, with an increase in the length of exposures and decrease in the distance, if it is deemed necessary after the idiosyncrasy of the patient is determined. These cases react very slowly, the treatment often extending over months. In one case four months was required before any effect was shown, and ten months before the final cicatrization of the mass. We must not fail to keep in mind the fact that a severe burn, in treating these cases, will pro-

duce a rapid increase in our growth and a rapid dissemination of metastases. In our earlier treatment, we lost a case of osteosarcoma of the tibia in its third recurrence by failure to observe proper precautions, a severe burn going on to a spectacular growth of the tumor with metastases, resulting in death.

Tuberculosis

Patients of a tubercular diathesis, or the thin-skinned, fair-haired, blue-eyed, blue-veined people, have a special idiosyncrasy to the X-ray and burn very much more readily than their darker brethren. A rule, which, while not infallible, is fairly general in its application, is that those people who are readily affected by sunlight are also readily affected by the X-ray.

Treatment of Pulmonary Tuberculosis. We have personally had little experience in the use of the X-ray for this purpose, but sufficient data has been obtained from competent workers in this line, to make it seem probable that, in early cases, the X-ray may prove quite efficient if properly applied. A high tube should be used, a distance of twelve or fifteen inches of tube

from patient, an exposure of back, axilla and anterior thorax instituted twice a week, and the patient watched carefully for the production of erythema, for increased evening temperature or other symptoms of septic intoxication. This includes an examination of the urine and blood. We must not forget that the rapid destruction of tissue produces an accumulation of toxines, and that we may kill our patient by auto-intoxication if we proceed too rapidly.

Treatment of Tubercular Bone Disease

The X-ray has comparatively little effect upon tubercular bone. It seems, however, to produce a certain amount of encapsulization, and where tuberculosis of soft parts is associated with our bone lesion, is very effective.

Tuberculosis of Soft Tissue

Tubercular white swelling of the joints very naturally comes in at this point. Where our process is limited to the synovial or other soft structures, immobilization and the use of the X-ray produces brilliant results. In this, as in all other classes of tuberculosis, a high tube at

a distance of nine, twelve or fifteen inches, with treatments stopping just short of the production of decided erythema, is best.

Tubercular Glandular Conditions

In no class of cases in which the X-ray has been used have the results been more satisfactory than in these. About seventy per cent. of all of this class of cases treated by us have been discharged cured. Even where we have caseous glands with secondary infection, with sinuses discharging large quantities of pus, the results have been equally good. In these latter cases, the first effect is a gradual cessation of discharge, the closing of our sinuses, a reduction in the size of the glands with their final disappearance, and eventually a smooth, white scar, freely movable, upon the deeper tissues. Where the glands have broken down and the skin is reddened, it is advisable to incise these glands and allow the free escape of the pus.

It is well to warn patients that a cure by this method in all tubercular conditions is very slow. Perceptible improvement even does not begin in many cases for three, four or even six months,

and in cases with extensive involvement one, two or even two and a half years may elapse before we are ready to discharge our patient.

In view of the caution with which we are obliged to proceed to prevent burns or auto-intoxication, it is only natural to expect a slow reaction, but our results are so good compared to other methods of treatment that they are worth waiting and striving for. Medical means and orthopedic procedures are indicated side by side with our X-ray.

In no class of cases that come under the care of the radio-therapist is the necessity to use great care in protecting all the surrounding parts so urgent. We must remember that tubercular patients burn with very slight provocation. Establish the tolerance of each patient, placing the tube at a distance of fifteen inches and gradually approaching the subject as the occasion requires.

Myoma of the Uterus

The treatment of myoma of the uterus, that is, the soft, spongy type with hemorrhage, by means of the X-ray, gives us remarkable results. The action of the ray in these cases produces a

destruction of the epithelial elements, an obliterating endarteritis, depriving the growth in part of its nourishment, and an increase in the fibrous elements. The end result is the production of a tumor more nearly purely fibroid in character. Of course, where we have a pure or nearly pure fibroma in the beginning, the X-ray is contraindicated, as it will merely tend to increase the fibrous elements. A high tube should be used at a distance of twelve to fifteen inches, the focus directed just above the pubes and obliquely downward, and the treatment continued for fifteen minutes three times a week, the patient being thoroughly protected as to surrounding parts. We rarely expect any result for the first two or three months, and the treatment must be continued for a year or a year and a half to get the maximum result.

The use of the *Tesla* current applied in the vagina by means of a vaginal glass vacuum electrode, blown to fit, the other terminal held in the patient's hand, is a very effectual adjuvant in stopping hemorrhage, as an analgesic and in absorbing plastic exudate.

CHAPTER X

TREATMENT OF DISEASED CONDITIONS BY MEANS OF HIGH-FREQUENCY CURRENTS

The selection of the particular current we are to use in the treatment of diseased conditions, depends upon the physiological action of that current. We remember that the static, the *d'Arsonval* and the *Tesla* current have in common, in varying degrees, the following attributes: First, the production of hyperemia; second, an increase in leucocytosis; third, an absorption of plastic exudate; and fourth, an increased germicidal action of the blood serum at the part treated; fifth, an obtunding of sensibility of terminal nerve filaments and a general sedative action. In general, that current which has the greatest amperage and the lowest frequency will produce the greatest hyperemia—that having the smallest amperage and highest interruption will be most sedative. The *d'Arsonval* and hyperstatic currents have the added effect of stimulating glandular tissue and acting

as stimulants of metabolism, the first generally, the second in a more local manner. Polarity is a matter of little moment in the application.

We must also bear in mind that the physiological action of the *d'Arsonval* current is just the same whether it is obtained from a single solenoid or from the primary of a hyperstatic transformer or the primary of an *Oudin* resonator, and that the action from the secondary of the hyperstatic transformer, the secondary of the *Tesla* transformer and the secondary of the *Oudin* resonator is exactly the same, also that this latter form of current is usually applied by means of vacuum electrodes, although metal ones can be used.

The regulation of the quantity of current used and the length of treatment are not so important as in the X-ray. No harm, but discomfort only, results from too wide a separation of the spark gaps. The length of treatment varies widely with the object to be attained, the more chronic the condition and the greater the need of hyperemia, the longer will be the time of each treatment. Roughly, from five minutes to half an hour is required to obtain results.

To Produce a Reduction of Blood Pressure and General Increase in Metabolism

The use of the *d'Arsonval* or hyperstatic (from the primary) currents, applied to the entire surface of the body or by means of flat, glass, vacuum electrode, results in a very appreciable fall of blood pressure. Treatment should be applied for from ten minutes to half an hour each day. Of course, we cannot expect, by this means, to affect the underlying cause in cases where a lesion exists. The increase of general glandular activity obtained by this means is marked, and is a great aid toward an improvement by producing the proper functionating of our organs and the increased elimination of poisonous products from our tissues.

These currents are better applied for this condition by means of the auto-condensation couch, the solenoid or the chair, already described.

The Tesla and Hyperstatic (from the Secondary) Currents as a Substitute for the Bier Congestion Treatment

In the *Tesla* current we have an ideal agent for the production of hyperemia, increase in

leucocytosis, absorption of plastic exudate, and increased germicidal action of the serum. It is, therefore, indicated in all that class of cases in which the *Bier* congestion treatment has proved so effectual. It is necessary, however, as in the *Bier* treatment, that an incision over the inflamed part sufficiently wide to allow of the escape of pus and serum, should be provided.

The above being true, it follows that in cellulitis and other forms of infection in which we are able to provide for an escape of serum or pus we have a valuable remedy at our command. The electrode can be applied over our bandages, provided they are not too thick, the time of treatment and quantity of current used depending upon the condition and the reaction obtained.

The treatment can be used as an adjuvant to other surgical procedures, and its only contraindication is an inability to provide for the escape of our septic material.

Treatment of Adhesions About Joints and Tendon Sheaths

The use of the *Tesla* current, applied by means of a flat, glass, vacuum electrode, with spark gaps separated so as to produce a considerable

bombardment, *i. e.*, as great a spark gap as the patient can stand, for from five to twenty minutes each day, is very effectual. It is necessary, of course, that the adhesions should be first broken up under an anesthetic (in some cases this must be repeated several times), the tendons being pulled through their sheaths by manipulation of the fingers and other parts. The analgesic effect of the current is considerable, and the absorption of plastic exudate remarkable. The hyperstatic current (taken from the secondary) may also be used for this purpose, if desired. A satisfactory result may be looked for in every case, even those most marked, if conscientious continuance is maintained. Massage is a valuable, in fact, a necessary adjuvant to this treatment, given after the high-frequency current. Passive and active motion, maintained regularly each day, is also absolutely necessary to a satisfactory result.

Acne Vulgaris—Acne Indurata

In these cases, the *Tesla* and hyperstatic (from the secondary) currents, applied to the affected part by means of a flat, glass, vacuum electrode, in such a manner as to produce a

considerable bombardment, can be used as an adjuvant to the X-ray or substituted for it. High-frequency alone is the author's choice. It must be applied over the entire surface, and is not at all disagreeable to the patient, as might be imagined. Five to fifteen minutes from three times a week to even each day in obstinate cases is indicated. Appropriate medical treatment, *i.e.*, the regulation of the diet and of the bowels together with proper cleansing of the skin, adds greatly to the efficiency of the treatment.

It is, however, remarkable what results we can obtain even in cases where the patient is careless in this regard.

The treatment should be maintained for a considerable time. From six weeks to three months is the length of time required in the usual case.

Cardiac Conditions

Piffard is very favorably impressed with the results obtained by means of high-frequency currents in chronic cardiac conditions, also in acute inflammations of the viscera, in eruptive fevers, typhoid fever and in pulmonary tuberculosis.

The choice of current will depend upon the condition, as will also its method of application, by means of the electrodes or generally by means of auto-condensation.

Dilatation of the Stomach, Gastroptosis, Enteroptosis and Intestinal Atony

The treatment of this class of cases has already been mentioned in this book. The results obtained by *Williams*, however, are so good that we quote him as follows: "After a number of applications, varying in different cases from ten to twenty, the stomach was found to have assumed its normal position and size, and the other parts of the intestinal tract to have returned to their natural relative positions. At the same time, in all but two of our patients the normal process of digestion was restored. It was, however, considered advisable to continue the dietary régime for some time longer. In one case there was no improvement, owing apparently to a radical fault in the gastric juice, hyperchlorhydria, although the stomach recovered its normal size. Treatment was given by means of the

Oudin effluve to the abdomen." (See atonic indigestion.)

Diabetes

Williams, as well as several continental authorities, report series of cases treated by means of the *d'Arsonval* current. Nearly all reacted favorably. In a number the sugar entirely disappeared from the urine, the thirst was alleviated and general increase in nutrition took place.

This corresponds with the results in the limited number of cases treated by the author. Appropriate medical and dietary treatment must, of course, be continued. The treatment may be administered by means of the auto-condensation method or by glass electrode over the abdomen.

Eczema

The treatment of chronic eczema by means of the X-ray has already been mentioned. As the author stated in that connection, however, he personally prefers the high-frequency currents in this condition, using, wherever possible, the *Tesla*. His results in this connection have borne out those obtained by

Piffard, namely, a relief from the itching, a rapid diminution in the infiltration and scaling, a softening of the skin and return to normal. Appropriate medical treatment is indicated in all these cases. Of course, unless the condition which produced the eczema originally can be relieved, there will be a prompt recurrence of the condition. *Oudin* gives preference to the current called by his name, and says that a few applications will do wonders in obstinate localized eczemas. Lichen planus, which is very resistant to ordinary treatment, has often disappeared in two or three weeks.

Furunculosis

The treatment by the X-ray of boils is much like that of carbuncle. The time, however, is doubled. One treatment is often sufficient for this condition.

As an adjuvant, the *Tesla* and hyperstatic (from the secondary) currents, applied by means of a flat, glass, vacuum electrode, are valuable, their analgesic effects are marked, and even without the aid of the X-ray, rather remarkable results can be obtained.

The pain is often completely relieved after one treatment, and a beginning slough may be looked for in case our treatment has been sufficient, within twenty-four to forty-eight hours.

Treatment of Exopthalmic Goiter

The *Tesla* or hyperstatic (from the secondary) current, applied over the cervical sympathetic by means of a flat, glass, vacuum electrode, or of less value the *d'Arsonval* in the usual manner, is recommended as an adjuvant to the X-ray in this condition. Five or ten minutes on either side in the case of the *Tesla* current, either alternating with the X-ray or used in conjunction with it, gives satisfactory results. The sedative action of all these currents is well shown in this condition. The nervousness is markedly diminished, and there is a fall of pulse rate at the end of the treatment often amounting to as much as thirty or forty beats. Patients usually complain of drowsiness, and in some the soporific effect is so marked that the patient falls asleep during the progress of the treatment.

This sedative effect, most marked with the *d'Arsonval*, usually lasts for from six to twenty-

four hours, its effect becoming more apparent as the treatment progresses.

Some observers have reported complete relief of all symptoms by this means alone. In our hands it has proved most valuable as an adjuvant to the X-ray.

Medical treatment, if desired, is not contra-indicated during the progress of our electro-therapeutics.

Treatment of Chronic Gynecological Conditions. Subinvolution of the Uterus, Adhesions of Uterus and Adnexia, Infiltration into the Broad Ligament, Metrorrhagia and Menorrhagia

In the above class of cases, in our hands the *Tesla* and *d'Arsonval* currents, applied by means of a vacuum glass vaginal electrode blown to fit the vagina, the other electrode held in the patient's hand, the treatments occupying from fifteen minutes to half an hour in extreme cases, two or three times a week, has given brilliant results. The quantity of current used varies with the tolerance of the patient and is controlled by the rheostat and the spark gaps.

The absorption of exudate and the relief of not too firm adhesions has been remarkable. The analgesic effect is almost absolute, and the general tonic and sedative effect as marked. A marked diminution in quantity in hemorrhagic conditions is obtained. In no class of cases is the result more brilliant. A reduction in the size of the uterus and an increased mobility early occurs; hydrosalpinx and to a less degree chronic pyosalpinx is reduced in size or even disappears. In short, applied properly and with intelligence, it is far superior in the results obtained to any other form of local treatment.

Acute gynecological conditions should never be treated by this means. This we will readily understand by reference to the physiological action of the currents. The treatment should also not be instituted too close to the menstrual period.

Hemorrhoids and Fissures of the Rectum

The treatment of the above condition is similar to that used in proctitis. The *Tesla* and the *d'Arsonval* currents have proved very efficient in our hands, applied by means of a vacuum glass

electrode in the rectum, the other pole being held in the patient's hand.

Atonic Indigestion of Stomach and Intestinal Origin

The use of the *Tesla*, applied by means of a flat, glass, vacuum electrode to the entire abdomen, the other pole held in the patient's hand, or the *d'Arsonval* current, for ten or fifteen minutes, either each or on alternate days, has yielded remarkable results. In chronic constipation the results have also proved encouraging.

Where the *Tesla* is used, the treatment is carried to the point of considerable hyperemia of the skin over the abdomen. (See dilatation of the stomach.)

Lupus Erythematosa

In the treatment of lupus erythematosa, we have, in the *Tesla* current, applied in the usual manner, a much more satisfactory procedure than the X-ray. We had one case under observation of eleven years' standing, treated by every other means, including X-ray, without result, in which we effected a cure in six months by this

method. In this treatment the spark gap length must be considerable and the bombardment carried to a degree of extreme congestion to get the most satisfactory results.

Recurrences are the rule and should be treated early.

Neuritis

In neuritis, high-frequency currents applied to the course of the affected nerve, give almost immediate relief. This relief lasts for from half an hour to six hours. Treatment should be applied each day for from five to fifteen minutes. In extreme cases it can be used twice a day. By this means we accomplish a double purpose, relieving the pain of the first and third stages, and keeping up the nutrition of the muscles during the regeneration of the nerve.

We also tend to limit in a degree the inflammation of the nerve and aid its regeneration.

In cases of simple perineuritis or of pressure upon the nerve from surrounding plastic exudate our results are often brilliant and always helpful.

The Tesla and d'Arsonval Currents and Static Breeze as a General Sedative and Tonic in Neurasthenic Conditions

In these conditions very satisfactory results can be obtained from either of the foregoing. The *Tesla* current may be applied by electrodes to the entire surface of the body, or the *d'Arsonval* by means of an auto-condensation couch or chair. A solenoid large enough to enclose the patient is also used by some operators. It is an unwieldy and bulky affair, however, and offers small advantage over the condensation couch or chair.

The application of the static breeze is made by means of the crown to which either pole from the terminal of the static current is attached. The patient is seated upon a platform with glass legs for insulation. The other pole is held in the patient's hand or is attached to a metallic plate upon which his foot rests.

The length of treatment varies from ten minutes to half an hour.

Orchitis

Guilleminot suggests the use of the *d'Arsonval* current in this painful affection, one pole, the anode, being applied to the testicle, the other to the spermatic cord. The treatments are given each day for ten minutes, and result in prompt relief of pain and in a rapid diminution in the size of the testicle.

Obesity

Piffard, *Williams*, *Oudin* and others report successful results in the treatment of obesity by means of the *d'Arsonval* and *Oudin* currents. Treatment is applied by means of auto-condensation, and should be continued for two or three months.

Pruritis Vulva and Pruritis Ano

In these cases the cause of the pruritis should be found and relieved. For the distressing local symptoms, however, the use of the high-frequency currents is very satisfactory.

Proctitis

In chronic proctitis, with or without ulceration, the *d'Arsonval* current, or even the *Tesla* current, yields very satisfactory results. We are able to obtain vacuum glass electrodes blown to fit the rectum. In fact, glass electrodes can be obtained or blown from our own design suitable for any purpose.

One electrode, the glass one, is inserted in the rectum; the other, a metallic one, is held in the patient's hand.

It is always the part of wisdom in using these currents to proceed with caution until we discover the degree of reaction in individual cases.

The *d'Arsonval* current is the current of choice in this condition, as in addition to the hyperemia, analgesia, absorption of exudate and anti-bactericidal effect, the function of glandular structures is markedly increased.

Lumbago and Chronic Rheumatism

In this class of cases, we have our choice of the static, the static induced, the hyperstatic or the *Tesla* current. Where the latter is applied, the spark gap length used should be consid-

erable, as a strong bombardment is essential, the production of extreme hyperemia with subsequent absorption of plastic exudate being the aim of our treatment. Our preference is for the *Tesla* current, as it is much more sedative and just as lasting in its effect.

The static or static induced currents can, however, be used with good results. In this event we use a metal ball or fine multiple spark electrode, the other pole held in the patient's hand attached to a terminal or grounded, depending upon the intensity of the effect desired.

The current is regulated by means of the spark gaps, the distance of the ball electrode from the patient and the rapidity of the bombardment. Massage as an adjuvant is very valuable. The treatment is applied each day for from five to fifteen minutes.

Pulmonary Tuberculosis

As the writer has said, he has but slight personal experience in this class of cases. *Piffard* reports results in the early stages by means of high-frequency currents. *Williams*, of forty-three cases reported in various stages,

all but three or four made good recoveries, at least so far as to enable them to resume their ordinary occupations. *Thielle* reports twenty-five cases, and found the cough modified from the beginning, expectoration diminished, bacilli disappear and in only one case reappear. In the majority of cases treated by these authors, the effect of the first few applications was to increase the temperature, diaphoresis, loss of weight and number of bacilli. In a short time, however, these conditions were reversed, the disease was apparently arrested, and in many there was every clinical evidence of permanent cure. The treatment was chiefly by auto-condensation, sometimes combined with the *Oudin* current.

Urticaria

Guilleminot reports remarkable results in the above condition by means of static or high-frequency currents, together with general treatment. As, however, this condition is so evanescent and liable to disappearance under almost any form of treatment, the author is somewhat skeptical as to the efficiency of the treatment.

Chronic Urethritis

Annealed glass, blown in the form of a small sound, attached to one wire of the *Tesla* or other high-frequency current, the other electrode held in the patient's hand, has been used for this purpose. It is undoubtedly effectual in stop-

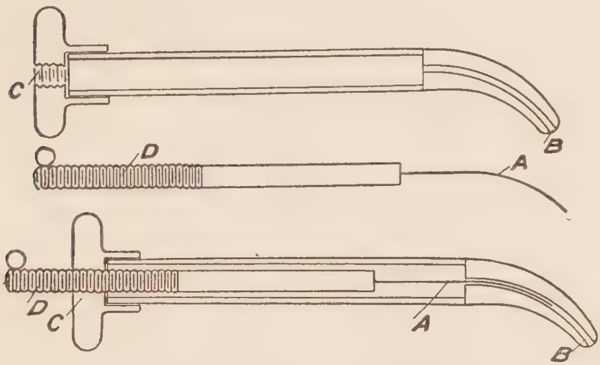


Fig. 47.—Illustrates the Keating-Hart electrode which is used for fulgeration. As the disk "C" is turned one way or the other, it moves "D" through it so that the copper wire "A" approaches the opening "B." In this way the length of spark is regulated. Keating-Hart's method of fulgeration consists simply in that after removal of a malignant growth by the knife, while the patient is under the general anæsthetic, a high-frequency current is applied thoroughly to every part of the raw surface. This current is strong enough to turn all of the tissues white. He claims that if this method is followed after an operation, that there is very much less danger of the return of a malignant growth.

ping the discharge. As to whether it will produce disagreeable by-effects or not, is a mooted point.

Fulguration

It has been discovered that the direct application of a naked, metallic point, derived from one terminal of a high-frequency current, the *Tesla* current preferred, the other terminal being held by the patient, will produce a dry necrosis of the tissue. In nævi, warts, hairy moles, tonsils and perforating or sluggish ulcers, this treat-

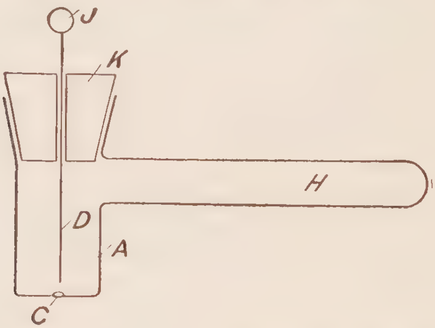


Fig. 48.—Is a modification of the Keating-Hart electrode. This consists of a glass shaped like a hammer and having a hole "C" through the bottom surface. "K" represents a soft rubber cork; "D" represents an insulated wire pushed down through the soft rubber cork, making the distance between the end of it and the patient adjustable. "J" is where the connection from the high-frequency apparatus is made to the electrode. This makes a very clean type of electrode for this purpose.

ment is ideal. An instrument (see Figs. Nos. 47 and 48) has been devised for this purpose. The metallic point projects from its glass insulation about one-thirty-second of an inch. This is approached to within about one-sixteenth of

an inch of the tissue. The strength of the current is controlled by means of the rheostat and the spark gap. From two to four minutes is sufficient for each treatment. The treatment is not especially painful, and should be repeated after sufficient time has been allowed to determine the extent of the death of the tissue. This is usually from four to ten days. When the eschar separates, a smooth, granulating tissue, or in some cases, a thin epithelium will be found beneath. From two to six treatments are usually sufficient for the removal of the tissue desired. No bleeding results, and the inflammatory reaction is not marked. We have not found it advisable, so far, to remove very large, vascular nævi by this means.

For the removal of tonsils we have in this agent an ideal method. It is bloodless, not very painful, and avoids the danger of hemorrhage in fibrous growths.

RADIOGRAPHIC RECORD

Family History . . . .

Previous History { Medical / Surgical / X-ray } Name of Physician . . . . .
Time since last X-ray Exposure .

Present Record . . . .

Style of Tube (Maker) . . . .

Make of Plate . . . .

Parallel Spark Gap Milliamperes . . . .

Interrupter { Wehnelt . . . .
Mechanical . . . . }

Position of Rheostat . . . .

Primary Current . . . .

Distance of Target from Plate . . . .

Distance from point of central ray to two landmarks . . .

Time of Exposure . . . .

Remarks . . . .

RECORD FOR X-RAY TREATMENT

Family History . . . .

Previous Treatment { Medical / X-ray / Surgical } By Whom . . . . . .

Diagnosis—Photo if possible—measurement and location involved . . . .

Present Treatment { Medical . . . .
Surgical . . . . }

X-RAY TREATMENT

Style of Tube . . . .
Ray Filter . . . .
Parallel Spark Gap Milliamperes . . . .
Interrupter { Wehnelt. Primary Current—position of Rheostat
Interrupter { Mechanical. Primary Current—position of Rheostat
Distance of Target from Patient . . . .
Time of Each Treatment . . . .
Number of the Treatments . . . .
Present Condition . . . .

APPENDIX

The art of radiography is probably the most difficult thing with which we have to deal in the study of the X-ray, and only through practical experience can any sort of success be attained. Two methods are of use in taking radiographs. One consists of relatively short exposures with a very high tube and a large quantity of current, the second relatively long exposures with a small quantity of current. The first gives sharper outlines to the shadows. The second will show better the varying textures of the tissues.

Radiography is valuable aside from fracture work in differentiating bony lesions, *i.e.*, syphilis, tuberculosis, and sarcoma; in revealing stone in the kidney, bladder and ureters (it is useless in determining stones in the gall bladder, their appearance in a radiograph being so rare as to be almost accidental); deformities of the pelvic and other bones; non-eruptive teeth, tubercular lesions of the lung, as well as calcarious de-

posits and collections of pus. Disease of the accessory sinuses of the head, while difficult of diagnosis, can usually be made out, showing darker when filled with pus.

In taking pictures of foreign bodies and of fractures, two radiographs should always be made in different planes. By finding the angle of incidence we are then able to determine the position of the foreign body or fracture. In place of this stereographic radiographs, which even more clearly define the condition, may be taken.

A negative result in an attempt to locate a stone in the kidney, bladder or ureter, must not be taken as indicating no stone. Certain varieties of stone cast so slight a shadow that they can not be diagnosticated by this method. It is also well to remember that hardened feces in the intestine are often taken for abnormal kidney shadows. In the vast majority of cases, however, a positive diagnosis, especially if accompanied by positive findings by means of the cystoscope and catheterization of the ureters, is sufficient to justify operative interference, with, of course, a good clinical history back of all this.

In no branch of radiography have our results proved more satisfactory than in differentiating bony lesions. Where the radiograph shows a normal bone shadow with the periosteum raised from the bone and but slightly thickened, a simple periostitis is indicated; where the periosteum is separated from the bone, thickened and with the bony structure beneath itself altered, *i.e.*, showing rarefied areas, syphilitic involvement is very probable; where the rarefied areas are confined to, or at least originate in, the medullary portions of the bone, tuberculosis is our diagnosis; while in sarcoma is found a clearly circumscribed tumor beneath the periosteum with apparently healthy bone beyond.

The accompanying radiographs illustrate rather aptly our foregoing remarks.

Figure No. 1 shows a fracture of the fibula at the junction of its lower third. No displacement had taken place in this case, and the diagnosis would have been exceedingly difficult without this aid. The picture was taken through a plaster cast heavy enough to allow the patient to walk about. It will be seen how slight an impediment this has been in making the radiograph.

Figure No. 2 shows a Pott's fracture reduced and in proper position. No surgeon is justified at the present time in resting satisfied with a fracture unless a radiograph shows the position of the fragments to be satisfactory.

Figures No. 3 and 6 illustrate this fact. No. 3 shows union in fair position of both bones of the forearm. No. 6 shows a badly reduced fracture of both bones in their lower third. By the older methods of diagnosis we should probably have been satisfied with this reduction; and yet, it is easy to see the amount of disability which would probably occur from the excessive formation of callus, even if the union in the radius had become firm.

Figure No. 4 shows two wrists, one normal, the other the seat of a tubercular osteomyelitis of considerable extent. In the normal wrist, sharp and clear definition of the carpal bones can easily be made out. In the abnormal one is seen the disintegration of several of the carpal and the heads of the last three metacarpals, the bones being replaced by granular tissue, allowing the penetration of the X-ray with greater ease than in the normal.

Figure No. 5 shows an impacted Colles' frac-

ture with considerable comminution of the head of the radius. The necessity of radiographs in two different positions is here clearly shown.

Figure No. 7 shows union in malposition of the upper third of the leg. This is a case that was by no means as easy to diagnosticate as would appear from the radiograph. The writer had the privilege of seeing this case in consultation before the picture was taken, and except for the shortening, very little could be made out.

Figure No. 8 shows unerupted teeth. This was a case of a man of thirty-five, who had had many obscure symptoms with many diagnoses, ranging from odontoma to osteomyelitis and sarcoma. The radiograph at a glance clears up the diagnosis.

Figure No. 9 shows calcarious deposits in the kidney, with a stone in the ureter just below its entrance into the pelvis. Operation in this case proved the accuracy of the diagnosis. It is well to bear in mind that no kidney picture is of value in which the transverse processes of the spines and the ribs do not show clearly.

Figure No. 10 shows a spontaneous fracture of the humerus due to osteo-sarcoma. This is

Fig. 1. Fracture of the fibula.

Fig. 2.—Pott's fracture of the ankle.

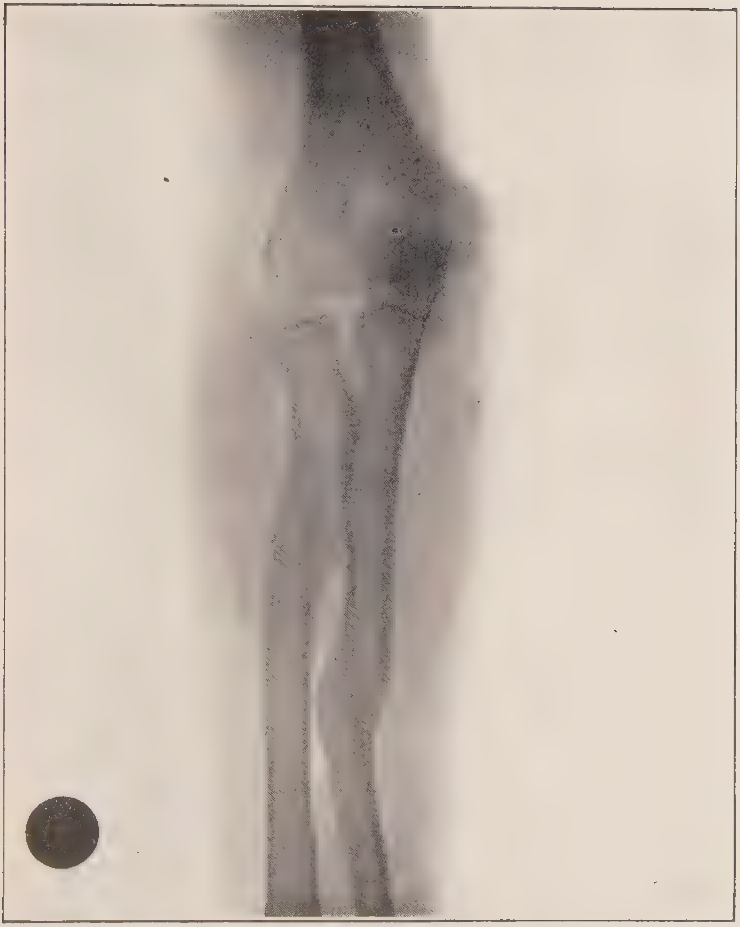


Fig. 3.—Properly united fracture of both bones of the forearm.

FIG. 4. Normal wrist and tubercular wrist.

FIG. 5.—Colle's fracture of the wrist.

Fig. 6.—Badly set fracture involving both bones of the forearm.

FIG. 7.—Improperly united fracture of the femur.

FIG. [illegible].—Non-erupted teeth.

FIG. 9.—Stones in the kidney.

Fig. 10.—Sarcoma of the humerus with spontaneous fracture.

often one of the most difficult diagnoses that surgeons are called upon to make. The radiograph, again, makes it exceedingly easy.

If we were called upon to determine in what class of cases the Roentgen ray has proved most valuable as an aid to diagnosis in our experience, we would say that to the internist it probably has its greatest use in clearing up obscure thoracic and abdominal conditions, ranging from stricture of the esophagus through aneurisms, collections of pus in and outside the lung, and tuberculosis, subdiaphragmatic abscess, and in malignant growths of the stomach and intestines and displacements of the viscera.

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